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EPOCH-MAKING BOOKS IN BRITISH SURGERY.

BY SIR D'ARCY POWER, K.B.E., LONDON.

VIII. CHESELDEN'S ANATOMY.

WE are accustomed to think of William Cheselden as a great operating surgeon; he thought of himself and was thought of by his contemporaries as an anatomist. In this sense the appreciation was correct: he made his living as a surgeon, but he was constant throughout his life to anatomy. He says: "The study of Anatomy, as it leads to the knowledge of nature and the art of healing, needs not many tedious descriptions nor minute dissections; what is most worth knowing is soonest learned and least the subject of disputes; while describing and dividing the parts, more than the knowledge of their uses requires, perplexes the learner and makes the science dry and difficult. In describing the part," he adds, "I have pretty much neglected the minutiæ in Anatomy; Nor have I been very particular about those things which cannot be understood without being seen, and being seen need little description; but have endeavoured to be more explicit about those which are of greatest use in Philosophy, Physic and Surgery. And I could wish the dividing and distinguishing of parts more usually done with more regard to these valuable ends." There is no doubt, therefore, that Cheselden was the first in England to write on surgical or, as it is now called, applied anatomy and thus began the long line of surgeons who based their knowledge on anatomy—a line which lasted until pathology—as different from morbid anatomy—gained the upper hand only so late as our own generation. Until the end of the last century every applicant for a post on the staff of a teaching hospital in London graduated through the dissecting-room; he now aspires through the pathological laboratory.

The first edition of "The Anatomy of the Human Body illustrated with twenty-three Copper Plates of the most considerable parts. All done from Life" appeared as a slender octavo volume of 271 pages in the year 1713, Cheselden being then twenty-five years of age. It proved an instant success; edition succeeded edition, until the thirteenth appeared in 1792, just forty

years after the death of the author. The popularity of the book was due in part to the simple language in which it was written and to the novel manner in which surgical cases were mingled with the drier anatomical facts; in part to its price ("Bound five shillings" is printed on the title page of the fourth edition, 1730); chiefly perhaps to the beauty and fidelity of the illustrations. When the plates of the first three editions were worn out, "having printed between three and four thousand, I have broke them to pieces, with intention to make a new set in which no expence shall be spared, and, as I have taken care to do justice to the buyers of the former editions by giving them leave to change their books at a low price; so I do intend, if I print another to act in the same manner." Three years later he fulfilled his promise by issuing to subscribers of four guineas the magnificent *Osteographia*, which only met with a moderate success. The plates were broken up when three hundred copies had been struck off, an additional hundred being reserved in case a Latin or French edition should be called for. Reduced copies of the plates were, however, used in the later editions of the octavo *Anatomy*.

Cheselden was a true artist and had a lively sense of humour. He posed each skeleton himself for the artist, with the result that the *Osteographia* contains such amusing figures as the one represented in *Plate I*. The drawings are also to scale and were made by means of a camera lucida as is seen in the frontispiece (*Plate II*), where Gerard Vandergucht is drawing; John Belchier is arranging the skeleton and Samuel Sharp is taking a note. Belchier and Sharp were the two apprentices of Cheselden, and both became distinguished.

The position between the old and the new teaching of anatomy is well illustrated by the earlier editions of Cheselden's *Anatomy*. The first three issues have as an Appendix "Syllabus sive Index humani corporis partium præcipuarum Anatomicus in xxxv Prælectiones distinctas." It gives in very bald Latin and in the approved manner of the schools the headings of the thirty-five lectures which Cheselden gave as his anatomical course. Abraham Chovet and Edward Nourse each issued a similar syllabus showing that they were private teachers independent of the United Company of Barbers and Surgeons. The three syllabuses are as dry as dust, but it should be remembered that from them, and especially from Cheselden's, came the Hunterian school and the surgery of the eighteenth century.

From the fourth edition onwards Cheselden published with his *Anatomy* "A short historical account of cutting for the Stone", in which he tells of "the first twenty-seven patients cut [by the lateral route] and I believe all are living. Indeed I had cut thirty-one who recovered before I had one died, having cut four more who recovered between the time the twenty-eighth was cut and the time he died. But I scorn to use any fallacious method of representing my success. Some of these being cut in the hospital and some privately, the truth of this account may be suspected by those who do not know me. I cannot take the liberty to mention the names of private patients therefore I will give a detail of those only which I cut this way in the hospital, where the first twenty-five recovered, to the truth of everyone of which I had above twenty witnesses, and I do believe these patients are all living at this time. Many of the children had the small-pox during their cure and some had the measles." From the tables he supplies Cheselden seems to have had

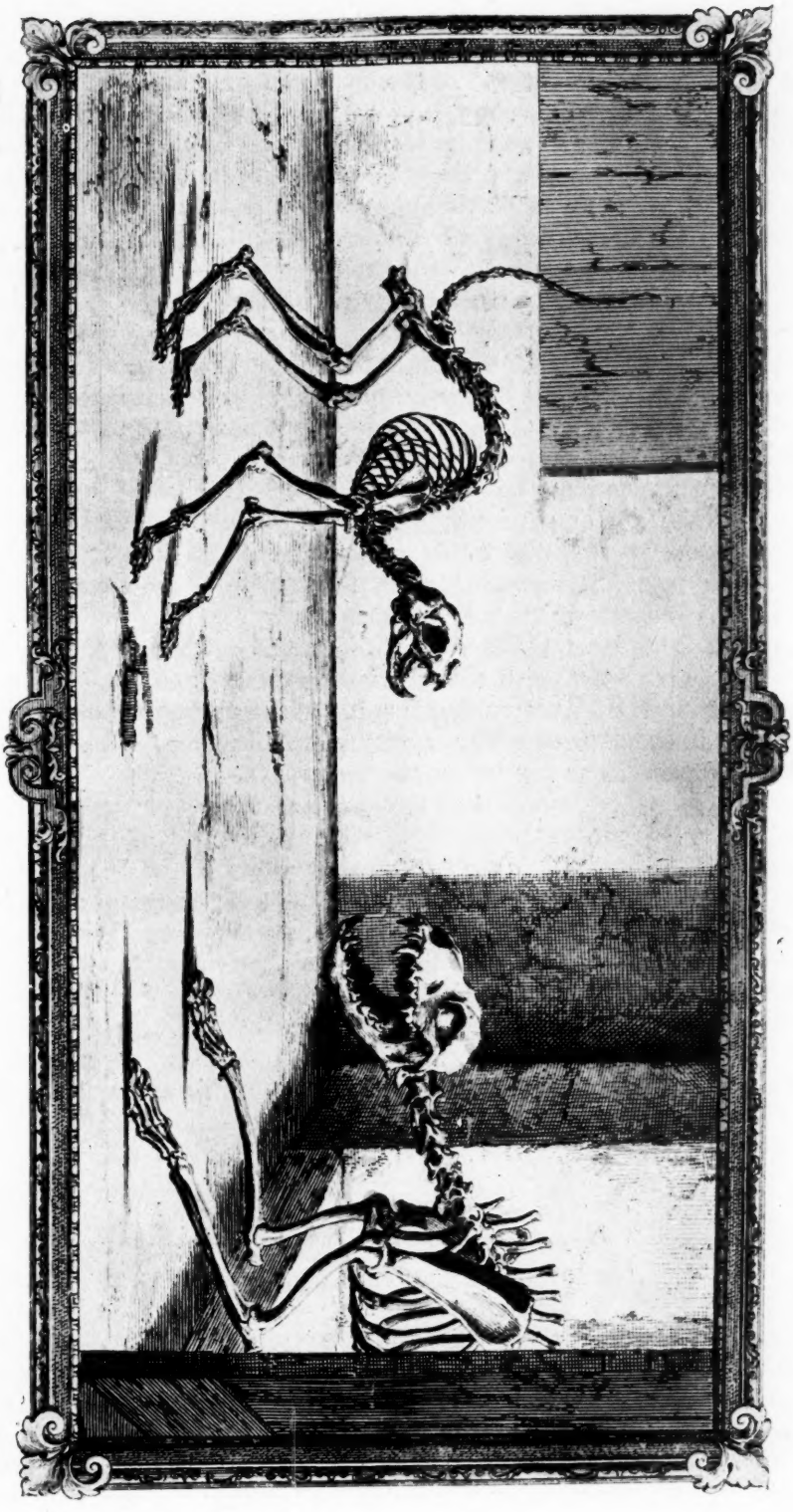

Plate I

regular field-days in his operating-theatre; thus, on March 27, 1727, he cut three persons for the stone; on April 12, 1727, four patients; again three on May 15, and so on to the end of the list in July, 1730.

The following passages show how he combined surgery with anatomy; speaking of the changes in bone he says: "A soldier that from a shot in his left groin, had the head of the Os Femoris broke, part of which came away through the wound, upon which the limb wasted, and, he dying of an Anasarca about a year after, I found the Os Femoris wasted about an inch in length, but so much in its thickness that when they were both dried and sawed lengthwise through their middles, the emaciated bone weighed thirty grains less than half the weight of the other thigh bone. From the appearance of this man and the firm connection of all the bones with their Epiphyses, I am persuaded he must have done growing before he received this wound; therefore unless he was taken lame into the service, which cannot be supposed, this bone must have wasted about thus much in that time."

Of the superior maxilla he writes: "Part of the sides of the cavities that lie next the nose are only membranes which make the cavities like drums, perhaps to give a grave sound to the voice when we let part of it through the nose. I have seen an imposthumation [suppuration] from rotten teeth in one of these cavities, which has been cured by drawing some of the last grinding-teeth, and by making a perforation into it through their sockets. The drawing one or two of the last grinding-teeth generally, if not always, opens a passage into the Antrum, but if not or if the passage is not large enough, it may be made or enlarged with a carpenter's nail-piercer or gimblet which is as good an instrument as can be for the purpose."

The levator ani is described as two pairs of muscles. "Fistula's in Ano that are within this muscle generally run in the direction of the gut and may be laid open into the gut with great safety; but those fistulas or rather abscesses that are frequently formed on the outside of the sphincter and usually surround it, all but where this muscle is connected to the Penis, cannot be opened far into the gut without totally dividing the Sphincter which, Authors say, renders the Sphincter ever after incapable of retaining the excrement. One instance of this kind I have known, but Mr. Berbeck of York, an excellent Surgeon and particularly famous for this operation, has assured me that he has often been forced to divide the Sphincter, which has made the patients unable to hold their excrements during their cure, but, the wounds being healed, they have retained them as well as ever."

Pricking the fascia in the antecubital fossa was always looked upon as a very disastrous accident when the barber-surgeon or his boy 'breathed a vein' with a dirty lancet. Cheselden explains the reason. "A puncture of the tendinous expansion of the Biceps cubiti Flexor is supposed to be always attended with grievous pain and inflammation and has, if we have not mistaken the cause sometimes proved mortal; yet the best of surgeons has given us instances of large tendons being cut and stitched without any bad symptoms and I have often seen them ulcerated and mortified without any more sign of pain than in other parts; so that I cannot see what the great mischief of pricking the tendinous Fascia is owing to, unless its laying so much upon the stretch which may be wholly avoided by bending the elbow and turning

OSTEOGRAPHIA,

OR THE

ANATOMY

OF THE

BONES.

MEDICAL SOCIETY OF CHIRURGICAL

BY WILLIAM CHESELDEN

SURGEON TO HER MAJESTY;

F. R. S.

SURGEON TO ST THOMAS'S HOSPITAL,

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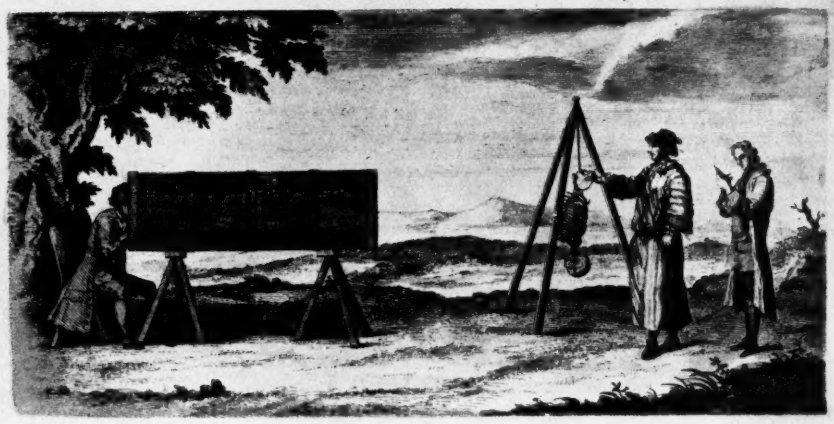

LONDON MDCCXXXIII.

Plate II

the cubit prone. Since I have considered this case, I have met with only one which was thus injured by an injudicious blood-letter who ordered the patient to keep her arm extended for fear of a contraction, and she was not without the most violent pain for a whole fortnight; but upon bending the cubit and turning the arm prone, she grew presently easy and, in a few days, well. Nevertheless I am persuaded that most of the accidents which are thought to be merely from blood-letting are critical discharges of some Disease, and from the puncture a small inflammation beginning, increases and suppurates. But however singular I may be in this opinion, I can be sure I am disinterested in it having never had any ill accident follow blood-letting in my life."

"The best way of extirpating the tonsil is, I think, by ligature; if the gland is small at its basis the ligature may be tied round it which I have easily performed by fixing the ligature to the end of a probe which I bent and so drew it round the gland and tied it. About five days after, the ligature growing loose I put on another in the same manner and then, in a few days, the gland dropped off. But meeting with another case of this kind, where the basis of the gland was too large to tie, I contrived an instrument like a crooked needle set in a handle with an eye near the point. I thrust this instrument with a ligature in it through the bottom of the gland and then taking hold of the ligature with a hook I drew back the instrument; then drawing the double ligature forwards I divided it and tied one part above and the other below in the same manner that I did to extirpate part of the Omentum in the cure of an Hernia."

And so the story goes on; Cheselden teaches anatomy and surgery together in a manner wholly different from his predecessors.

Gerard Vandergucht, his artist, was born in 1696. He was elder son of Michiel Van Der Gucht, a Flemish engraver who came to England and was a pupil of David Loggan who engraved the well-known plates of the Colleges at Oxford and Cambridge. Gerard was employed by Sir Hans Sloane as well as by Cheselden, but he worked chiefly for the booksellers until he became a dealer and opened a 'Gallery' in Lower Brook Street. He died in 1776, his wife surviving him, the father of thirty or forty children, of whom Benjamin, the thirty-second, followed his father's profession.

THROMBO-ANGIITIS OBLITERANS:

WITH SPECIAL REFERENCE TO A CASE INVOLVING THE SPERMATIC VESSELS.

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INTRODUCTION.

In 1908 Leo Buerger defined and named the condition of thrombo-angiitis obliterans; he rescued it from the lumber heap of gangrenes of unknown origin. His work is still the most authoritative on this entity. Buerger's disease remains to-day a subject of perennial interest because of its fatal character, the suffering and disability it causes in young people, the relative brutality which must be resorted to in the endeavour to stay its course, and the obscurity as to cause which envelops the affection. It is a disease which is now well known in those of its manifestations which affect the limbs; that it may affect other parts of the body is barely hinted at, and it is a matter of such profound importance that any light on this aspect of the condition must necessarily be put before the medical public as clearly as possible. This must be the excuse of the authors for publishing in detail the clinical and pathological aspects of a case of thrombo-angiitis of the spermatic vessels.

To make clear important clinical distinctions between the condition in the spermatic vessels and in the limbs, it is necessary first to review briefly the known facts of the disease in its typical peripheral distribution; subsequently the case will be dealt with fully.

Etiology.—Many theories have been put forward to explain the condition; syphilis has been suggested as a causative factor, but in a close study of thirty cases Buerger and Kaliski[1] showed that there is no connection between these two disorders.

Buerger's[2] view is as follows: "The disease is not an endarteritis obliterans; it is an occlusive thrombotic process involving the deep arteries and veins of the upper and lower extremities, or the superficial veins; the early stages of the disease manifest themselves in an inflammatory lesion which shows a specific and characteristic morphological picture while in the process of healing; and that in the early or acute stage purulent foci make their appearance which would suggest a microbial agent or infectious causative factor. No organism, however, has as yet been demonstrated, even in the superficial veins when these are in the stage of acute inflammation."

Rabinowitz,[3] however, claims to have isolated a bacillus from the blood of the local lesion and from the general blood-stream. This organism has

been subcultured, and after inoculation has produced lesions in experimental animals similar in gross and microscopical pathology to those seen in the disease thrombo-angiitis obliterans.

Oppel[4] considers the etiology from an entirely different aspect, namely, that the condition is due to hyperactivity of the suprarenal glands. He states that the theory is largely based on the fact that the blood serum of these patients contains a larger quantity of vasoconstrictor substances than the serum of healthy people. He elaborates the theory further by supposing that there is an excessive constrictor effect on the vasa vasorum followed by intimal degeneration and secondary thrombosis. This theory is the basis of the operation of unilateral epinephrectomy which he performs for the disease.

Dmitrijew[5] considers the cause to be hyperfunction of the suprarenal glands, and supports this by citing Duchinowa, who found an increase of vasoconstrictor substances in the blood six weeks after suprarenalectomy. Lettule, Marchak, and Boyer[6] conclude on both clinical and histopathological grounds that the disease is an entity resembling leprosy, tuberculosis, and syphilis, due to some specific, but as yet undetermined, cause.

Only 3 of Buerger's 500 cases occurred in women, and only 4 of the 500 were not Jews. Telford and Stopford[7] comment on the latter observation as follows: "The disease has in fact been called 'Die hebraische Krankheit'. This, however, can be no more than a topographical accident; each of our 4 cases was British." Tobacco smoking is held by Buerger and others to be an important predisposing factor, which probably acts by bringing about changes in the wall of the vessels, rendering them liable to attacks of inflammation and thrombosis. The onset is commonly in the third decade.

The great diversity of etiological factors which we have quoted indicates that there is still no settled or definite opinion as to the cause of this disease.

Distribution of the Lesions.—These affect one or both of the lower limbs in the vast majority of cases; in some the upper limbs are affected also. Regarding the participation of vessels other than those of the extremities, Buerger[8] says little is known. He has noted the 'old type' of occlusion in the spermatic artery, and in a branch of the gastric artery; of profound interest, however, is a case in which he observed the typical 'acute' lesions in the spermatic vessels of the cord. In a young man who consulted him for a subacute enlargement of the testis, epididymis, and cord, the diagnosis of tuberculosis of the epididymis or thrombosis of the vessels of the cord was made. Orchidectomy yielded an interesting specimen in which most of the veins of the cord and tributaries about the testis were thrombosed. Microscopic examination revealed typical 'acute lesions' in many of the vessels.

In *Keene's Surgery* reference is made to a case in which Murphy observed the disease in the renal vessels.

Signs and Symptoms.—These have only been described as they affect the limb vessels. Clinically the first stage is often an acute phlebitis of the superficial veins. The arteries may escape for years. Some swelling and heaviness of the feet may occur, and often there are tender inflammatory nodules in and below the skin. Later there is, as a rule, complaint of pain

in the legs. The symptom of intermittent claudication is very usual. The pains, at first intermitting, later become continuous and excruciating. Pronounced vasomotor and trophic disturbances occur: erythromelia, ischæmia, cyanosis, ulcers, and gangrene. Such is very briefly the clinical aspect.

Treatment.—Mueller[9] states that we have nothing to offer the patient which assures any reasonable promise of success, except amputation. Stradin[10] and others report good results from Leriche's sympathectomy. Koyano[11] states that Ringer's solution given hypodermically makes amputation superfluous; the intravenous method is the most general (Silbert).[12] Stühlern[13] reports good results with small doses of pilocarpine and insulin. Philips and Tunick[14] claim remarkable results with X rays which they attribute to the effect of the irradiation on the paravertebral sympathetic ganglia, and to the alterations produced in the circulating cellular blood elements (phagocytosis). Oppel's epinephrectomy has been alluded to above.

CASE REPORT.

P. L., age 28, Russian Jew, produce buyer, moderate cigarette smoker, consulted one of the authors (Lee McG.) in private on Dec. 14, 1927. His complaint was of a dull nagging irritation over the penis, left half of scrotum, and lower abdominal wall. This recurred daily and lasted for two to three hours. It was not sufficiently severe to interfere with work.

History.—On Nov. 15, 1927, the left testis was a little swollen and very painful. His doctor confined him to bed for four days. The previous history regarded children's diseases only, and venereal disease was denied. The family history was irrelevant.

Examination.—The left testis was a trifle smaller than the right; the epididymis contained two nodules in the caput and one in the cauda. The cord was perhaps a trifle thick (note taken at first examination). Sensation in testis normal. Per rectum, prostate and vesicles were normal; urine and urinary history normal. Other systems normal. Cutaneous tuberculin test gave a positive finding. Wassermann negative.

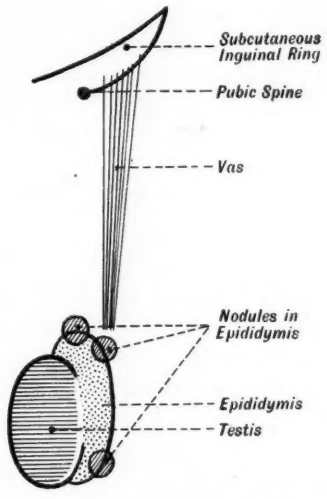

Fig. 407.—Diagram representing the condition found at the second clinical examination. Observe nodules in epididymis and thickening of upper part of vas.

A tentative diagnosis of tuberculous epididymitis was made, a suspensory bandage ordered, and the patient told to report in two months. When further examined on Feb. 12, 1928, discomfort was less in scrotum. The nodules were considerably bigger. The vas deferens was as thick as a lead pencil at the external ring and much less thick at the upper pole of the testis. This was noted. (*Fig.* 407.)

A confident diagnosis of tuberculous epididymitis was made and operation advised. A urologist confirmed both this and the suggested treatment.

Operation.—On Feb. 15, 1928, under general anæsthesia, the testis was

removed with the cord as far as the internal ring. The wound healed by first intention, and the patient left hospital on the tenth day after operation.

The macroscopic appearances of the specimen are dealt with later; here the only point requiring notice is the condition of the vas. On dissection the vas deferens was found to be normal. The apparent thickening of its upper part detected clinically was due to the firm adhesion of many blood-vessels to the periphery of the vas, giving the impression on palpation that this tube was much thickened.

PATHOLOGICAL REPORT.—" Buerger's disease of the vessels of the cord." On receipt of this report a complete examination of the peripheral pulses revealed no abnormality.

POST-OPERATIVE PROGRESS.—For a week the patient had slight shooting pains up the right cord. These lasted perhaps five minutes at a time. They recurred daily. A nodule the size of a pin's head was felt in the cord near the testis. Vas normal. On March 13 the pains in the cord were much decreased, and on April 24 the patient said he still felt occasional discomfort in the right cord.

PATHOLOGY.

Since Buerger[8] established beyond doubt that thrombo-angiitis obliterans is a definite entity and not to be confused with arteriosclerosis, many cases have been reported from various parts of the world. Notwithstanding the extent of the literature, comparatively few cases showing the acute lesions have been described. The rapidity with which the disease passes through the acute stage to the final healed process, the failure on the part of most patients to consult their medical advisers until the condition has become well advanced, and operation not being resorted to until more conservative treatment has failed to give relief, seem to explain satisfactorily the lack of material obtained for examination at this stage.

This difficulty of obtaining material in the acute stage has necessarily given rise to doubt whether thrombo-angiitis obliterans begins with an acute manifestation or not,* and the doubt will probably remain until many more cases showing purulent foci and giant-cell formation have been investigated. It is possible that the acute lesions may be found in conditions other than thrombo-angiitis obliterans, for Koyano[11] and Krampf[16] claim to have found the same type of inflammation in acute thrombosis in infections. Be that as it may, the sequence of events leading from the initial acute change to the final stage of organization and canalization, so clearly shown by Buerger in both superficial and deep arteries and veins,[17] suggests that, if not pathognomonic of thrombo-angiitis obliterans, it at least does occur in this disease. It i hoped that the histopathology of the present case which is described below will forge one more link in the chain of evidence in favour of this assumption.

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* Perla[15] states: " It is therefore of some significance that Buerger's so-called 'specific lesion' is never seen in the deeper arteries and veins, the *primary* seat of the disease. The lesions described in the migrating phlebitis are in all probability *not* specific for thrombo-angiitis obliterans."

Briefly, the changes found and described by Buerger in thrombo-angiitis obliterans are, in chronological order: infiltration of the coats of the vessels and surrounding tissue by inflammatory cells, occlusive thrombosis of the affected part of the vessel, the formation of purulent foci in the clot, replacement of the leucocytic areas by altered angioblasts and giant cells, organization of the 'bland' portion of the clot *pari passu* with the same change in the giant-cell foci, and canalization of the organized tissue—the final product being organized and canalized vessels, associated with matting together of arteries, veins, and nerves by inflammatory fibrosis.

The spermatic vessels (*Case* P.L.) show all these changes; the veins are affected much more than the arteries, but the acute manifestation is confined to the veins. The spermatic vessels are slightly different in appearance and

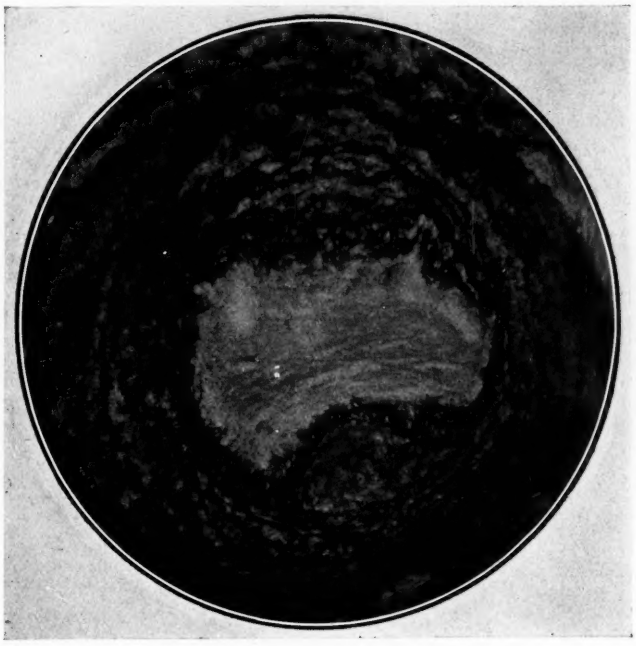

FIG. 408.—Section of a vein stained by Weigert's elastic-tissue stain. The elastic tissue is more abundant than, but not so clearly defined as, that seen in the veins of equal calibre in the extremities.

distribution from those of the limbs. The arteries are small and few, the veins comparatively large, tortuous, and numerous; there is less supporting connective tissue, but elastic tissue is more abundant, both in the surrounding tissue and in the walls of the veins, while, in addition, it is less clearly defined than in other veins (*Fig.* 408).

The difference in the vascular distribution probably has no direct bearing on the lesion itself, but the large venous return compared with the small arterial supply probably accounts for the fact that the veins have suffered more than the arteries.

Many cases in which the vessels of the lower limbs were affected have been examined by one of us (F.W.S.), but in these the disease had lasted

many months or years and the histological picture showed only the chronic stage. In the case affecting the spermatic vessels, however, we have been more fortunate in that all stages of the disease are represented.

The macroscopical appearance of this specimen showed very little in the way of gross pathological change. There was slight general thickening of the cord and epididymis, somewhat more marked at the upper end of the cord. A few definite nodules were present at the upper and lower ends of the epididymis. These on section appeared to form part of the organ, were yellowish brown in colour, and quite unlike tuberculous aggregations. Transverse sections of the vessels of the cord and epididymis showed a varied type of occluding mass. In some vessels it was soft and red, in others firm, elastic, and white in colour. There was no definite abscess formation distinguishable

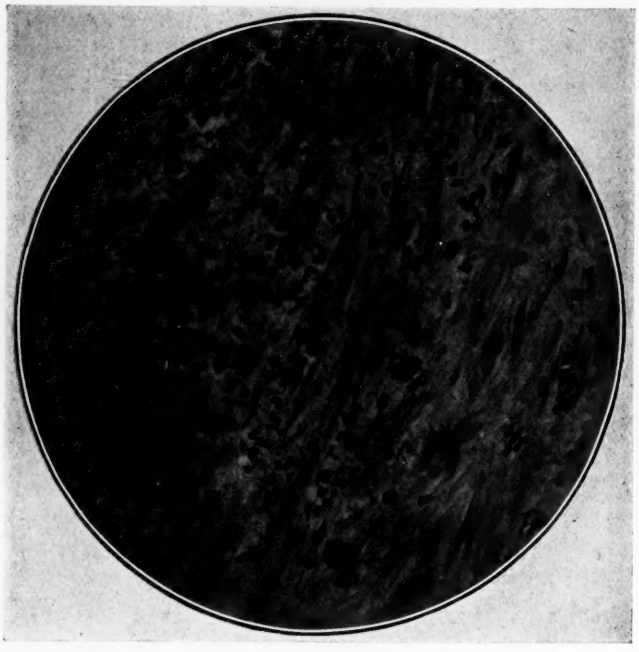

FIG. 409.—Showing the earliest acute manifestation. The muscle fibres of the media are seen separated by acute inflammatory cells, chiefly polymorphonuclears. The lumen of the vessel is above and to the left, where a giant cell may be seen in process of formation.

to the naked eye. The body of the testis showed no pathological change, and this was confirmed by subsequent histological examination.

Apart from the testis, sections were cut from many parts of the cord and epididymis, and these were taken, roughly, in serial manner in order to trace the change in type of inflammation in individual vessels. As the vessels in sections from the various parts were found to be affected in much the same way, a general description of the changes will suffice. For purposes of description, reference will be made to the microphotographs of the lesions in the affected spermatic vessels.

In *Fig.* 409 the disease is seen in its earliest manifestation. Besides the infiltration of the connective tissue surrounding the vessels by acute

inflammatory cells, the muscle fibres of the vascular wall are separated by the same type of inflammatory cells, as shown in the photograph. There are chiefly polymorphonuclear leucocytes, but a few large round mononuclears are also present.

In *Fig.* 410 the lumen of a vessel is seen filled with soft clot. The clot is composed of fused platelets, fibrin, and red and white cells. The white cells are slightly increased in numbers, but not more so than could be explained by a general and local leucocytosis. Thomas[18] has noted a persistent leucocytosis in early stages of the disease, so it is conceivable that a leucocytosis may show itself in the clot and be even more evident in the region of a local inflammatory process. As the disease progresses, miliary accumulations of polymorphonuclear leucocytes make their appearance at the periphery

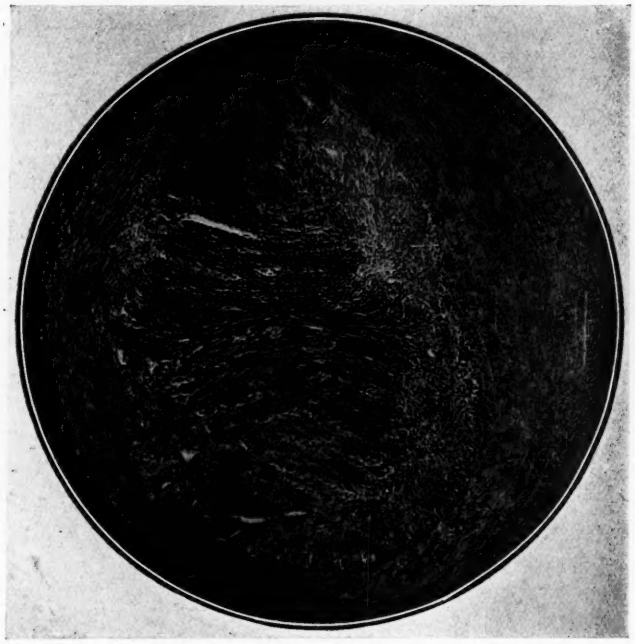

FIG. 410.—A large vein completely filled with clot, the greater part of which is of the bland type. A few giant-cell foci are present at the periphery, and where these are absent organization by the simple method is taking place.

of the clot (Buerger's purulent foci) (*Fig.* 411). To form the foci, these cells can be seen wandering in from the vessels of the media. In some of the smaller collaterals the whole of the occluding thrombus may be replaced by the acute inflammatory cells. Passing to the next stage, such a focus as seen in *Fig.* 412 shows almost total replacement of the polymorphonuclear leucocytes by altered angioblasts. The angioblasts attempt to penetrate the leucocytic area in order to form new capillary sprouts, having for their object the removal of the exudate as a preliminary to organization. The nature of the irritant in the leucocytic area prevents this, and the angioblasts become distorted and take on an irregular arrangement. Apparently some are able to enter and proliferate to form well-defined giant cells. The

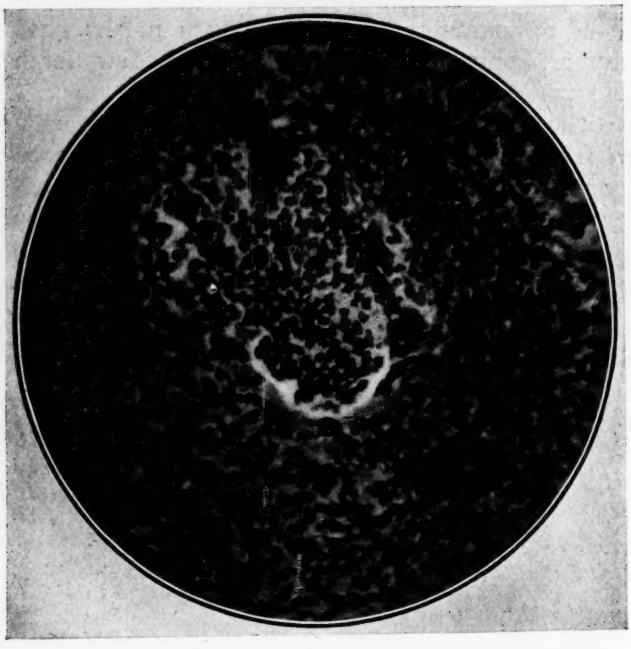

FIG. 411.—A ' purulent focus ' in the peripheral part of the clot in a vein. Numerous polymorphonuclear cells are seen wandering towards this centre of infection.

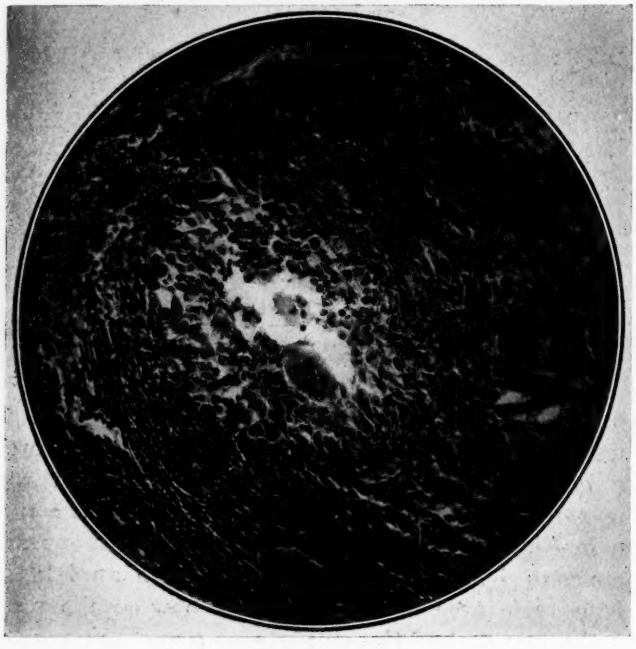

FIG. 412.—Showing the peripheral part of the thrombus. Above and to the left is the vessel wall, to the right simple organizing tissue, and below a mass of fibrin. A giant-cell focus nearing completion is shown in the centre. The periphery of the focus is already replaced by angioblasts, the centre is occupied by a giant cell and a few remaining polymorphonuclear leucocytes.

FIG. 413.—A vessel showing a small central zone of fibrinous clot. At the periphery several giant-cell foci may be seen, some of which have become partially organized.

FIG. 414.—Two very large giant cells are shown, with numerous nuclei aggregated in the centre. The giant cells occupy the centre of partially organized foci.

giant cells often attain to a large size, are irregular in shape, and the numerous nuclei tend to form aggregations in the centre of the cell. When the leucocytes of the purulent foci have disappeared and angioblasts and giant cells have taken their place, the foci have a superficial resemblance to early tuberculous nodules, but a careful analysis will show how they differ. The central aggregation of nuclei is quite unlike the peripheral arrangement of the nuclei in the typical giant cell of syphilitic and tuberculous lesions; there is never any caseation; small mononuclear-celled infiltration at the periphery of a focus is absent, and, although carefully searched for, neither spirochætes nor tubercle bacilli have as yet been found. The replacement of pus-cells by large mononuclear cells is evidently an intermediate stage in a special

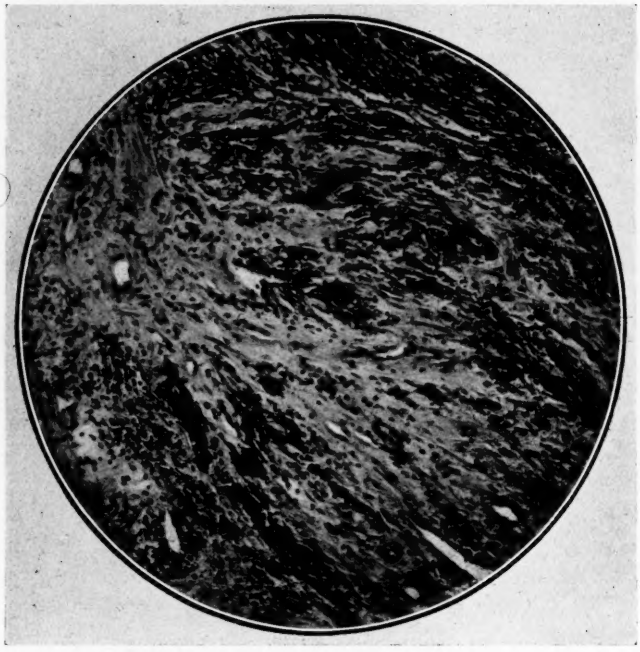

FIG. 415.—Shows admirably the organization of the bland portion of the clot. On the left is the wall of the vessel from which new vessels and fibroblasts can be seen growing in to replace the constituents of uninfected thrombus. The darkly staining material is fibrin.

healing process, and this is not seen so definitely demonstrated in other forms of inflammation.

On completion of the giant-cell focus (*Figs.* 413, 414), capillary buds grow in from the vasa vasorum, accompanied by fibroblasts from the intima, and fibrous tissue is laid down. The giant cells are often last to disappear, and sometimes remain in evidence long after organization is complete in the remainder of the obturating mass. At the same time as the purulent foci are undergoing these changes, organization of the bland portion of the clot is proceeding by a simpler method. There is no intermediate replacement of the constituents of the clot by angioblasts, but young capillaries and fibroblasts grow in, the fibrin, platelets, etc., are absorbed, and the

whole mass is converted into young connective tissue (*Fig.* 415). The characteristic appearance of the occluding thrombus at the termination of this stage is a diffuse distribution of young capillaries lying amongst fibroblasts and small mononuclear and plasma cells (*Fig.* 416). In addition, in some vessels, there is a deposit of iron-containing pigment derived from liberated hæmoglobin from broken-down red corpuscles. The capillaries in different parts of the thrombus communicate, and in many vessels the continuity of the lumen is re-established, although only to a limited extent. With increasing dilatation and function, many of these new canalizing channels develop definite muscular coats and elastic tissue in the walls. Some of the arteries show thickening and increased corrugation of the internal elastic lamina,

FIG. 416.—Showing a part of a vein. The obturating mass shows diffuse distribution of young capillaries and early canalizing vessels lying amongst fibroblasts and small mononuclear and plasma cells.

but no reduplication or fragmentation worthy of note has been detected in the veins or arteries.

While the above description gives the sequence of events in this intermediate stage of organization, o ten in old-standing lesions the occluding mass is seen to be infiltrated by enormous numbers of cells ; capillaries are few and connective-tissue corpuscles scanty, the picture presenting the appearance of chronic inflammatory granulation tissue.

Under normal conditions a vessel the seat of simple thrombosis may ultimately become converted into a fibrous-tissue cord, which represents the fibrosed wall enclosing the organized thrombus, but if infection is present in the thrombus, and if it continues, organization is indefinitely delayed. In

thrombo-angiitis obliterans, infection in a mild and chronic form is probably continued after the acute manifestation has subsided; this may account for the changes simulating chronic inflammatory granulation tissue in the older forms of the disease.

The acute inflammatory infiltration of the media of all vessels is soon superseded by cuffing of the new inflammatory vessels with cells of a chronic type, accompanied by a certain amount of fibrosis. A similar change occurs in the adventitia and surrounding supporting tissue, terminating in replacement of the normal fatty and loose connective tissue by inflammatory fibrosis, giving rise to matting together of arteries, veins, and nerves. (*Fig.* 417.)

FIG. 417.—This vessel shows the old or healed stage of the disease. The vessel is surrounded by inflammatory fibrosis. Many new vessels are present in the adventitia, and the lumen is occluded by a connective tissue, which is heavily infiltrated by small mononuclear and plasma cells. Numerous canalizing vessels may also be seen.

Fig. 418 typifies a change seen in some of the arteries. Below and to the right a canalizing sinus is seen eccentrically placed, crowding the organized clot into a crescentric mass. In the same artery, stained by Weigert's method to show elastic tissue (*Fig.* 419), points of difference between this lesion and those of atheroma and arteriosclerosis are brought out. In atheroma there is degeneration in the deeper parts of the thickened intima; this is absent in our case. In arteriosclerosis there is hypertrophy of the elastic tissue, with splitting off of new laminæ from the internal elastic lamina, these laminæ appearing in the new-formed tissue of the thickened intima; this is also absent in our case.

With regard to the histological diagnosis of these changes in the spermatic vessels, there can be little doubt that we are dealing with a case of

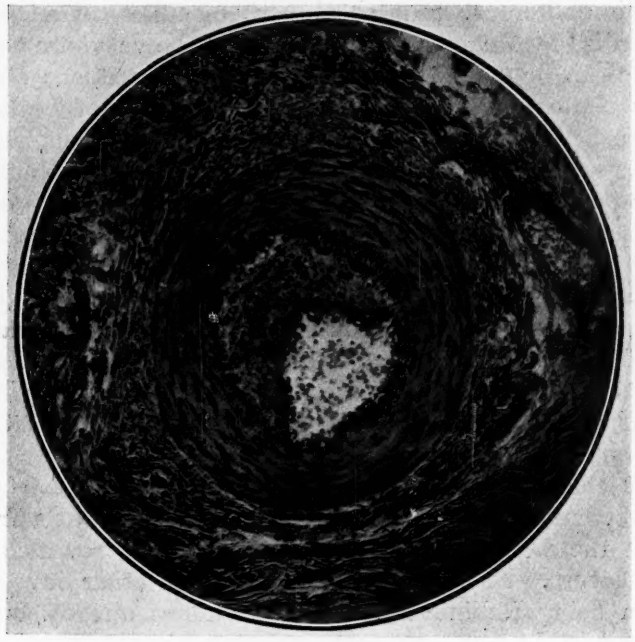

FIG. 418.—Section of an artery showing the inflammatory fibrosis surrounding the vessel. Numerous small mononuclear cells and new vessels may be seen in this tissue. The muscular coat is apparently healthy. The lumen is partially filled with new-formed connective tissue, and one large canalizing sinus is shown below and to the right. The new-formed connective tissue in the lumen is composed of cells arranged in an irregular manner. There is no evidence of degeneration or calcification.

FIG. 419.—This shows the same artery as in *Fig.* 418 stained by Weigert's elastic-tissue stain. There is no fragmentation of the elastic lamina. Elastic tissue has developed in the wall of the large canalizing sinus.

thrombo-angiitis obliterans, as it so clearly resembles, in all its phases, the disease as described by Buerger. It is true that the veins are chiefly affected, but the disease can be traced step by step in serial sections of these vessels, from the first acute manifestation to the final stage of healing. There is every reason to believe that the arteries have passed through the same succession of changes, since the healed product is the same in both arteries and veins. The differential diagnosis between thrombo-angiitis obliterans and granulomata, such as syphilis and tuberculosis, should present no difficulty. Apart from the absence of history of these diseases and a negative Wassermann reaction, as has been shown already, the histological picture reveals several points of dissimilarity. In addition, an interesting feature is shown in the case of thrombo-angiitis associated with syphilis reported by Smith and Wells Patterson,[19] namely, giant-cell foci may be seen lying external to the internal elastic lamina, a distinguishing feature not yet seen in the lesions of thrombo-angiitis obliterans.

There yet remains the possibility of some specific bacterial infection other than tuberculosis or syphilis. Sections of the vessels from this case, treated by all the well-known bacterial stains, have revealed no organism of a specific nature. This is in agreement with other investigators; the only exception being Rabinowitz, whose work has already been mentioned above.

DISCUSSION OF THE CASE.

It is noteworthy that the patient was a Russian Jew, 28 years old, a cigarette smoker and non-luetic.

Clinical Diagnosis.—There existed in this case before operation 'no differential diagnosis' (to quote a surgeon at St. Bartholomew's Hospital). It was thought that no condition could mimic tuberculous epididymitis so closely as this did. Gonorrhœa could be excluded, also the nodules were extremely unlike those of gonorrhœa.

In view of the pathological finding the most outstanding features are two: (1) The subjective nagging pains—tuberculous epididymitis is usually painless; (2) The thickening at the *upper end* of the vas. This thickening excited interest at the time it was observed. In tuberculous epididymitis the thickening in the vas begins at the testicular end and travels up. In this case the vas approximated to normal below, but became thicker as it was traced up. This was found to be due to the thickened veins and thrombosed vessels so adherent to the vas as to be taken as part of it.

Because of the rarity of the condition and the entire lack of knowledge (except Buerger's case) of the clinical picture, this condition of the cord is of the very first importance.

Buerger mistook his case for tuberculous epididymitis, precisely as was done in this case. The mistake is so easily made because the condition apes tuberculosis (note positive von Pirquet) so closely that one does not consider a differential diagnosis. The nodules (thrombosed veins) are indistinguishable from tuberculous nodules. It seems to the writers that the only conditions likely to assist the distinction are: (1) The dull testicular pains distributed to the penis, affected side of the scrotum, and lower abdominal wall; and

(2) The characteristic thickening of the upper part of the vas. This, in association with nodules in the epididymis, would seem to be pathognomonic of thrombo-angiitis obliterans of the vessels of the spermatic cord.

Finally, and in repetition, the case presents itself as follows: A young man, 28 years of age, of Russian Jewish extraction, who smokes, complains of dull nagging hemi-scrotal pains, radiating medially and upwards. He has one or more nodules which seem to be in the epididymis. These nodules are slightly tender and are exactly like tuberculous nodules, and the vas is much thicker above than below.

Prognosis.—The disease is characterized by relapses, so that the prognosis is always doubtful. The outlook, apart from operation, must be extremely bad as regards the testis. The main vessel to the testis is the spermatic or testicular; if this becomes occluded, the branch of the superior vesical which goes to the vas may vicariously supply the testis, but it is extremely doubtful if this latter vessel would escape the disease. The prognosis for the organ is therefore bad, and gangrene is a conceivable termination. The prognosis for life is good if the disease is localized to the scrotum.

As regards the other testis, from what is known of the disease of the limbs there is a strong possibility that it may become affected with the lesion sooner or later. It is unwise to tell the patient this. A brother or some member of his family should be warned. These subjects are frequently foreign Jews, with marked neurotic taint. Our own patient is already suspicious because of the pains he has had in his remaining testis since operation.

Treatment.—Perusal of the literature and prolonged observation of these cases of Buerger's disease leave the conviction that the vast majority ultimately require amputation of limbs. The other methods of treatment may and do relieve symptoms temporarily, but it seems to the writers that this result is entirely dependent upon the collateral circulation and the stage of vascular occlusion reached. The time, however, ultimately arrives when gangrene occurs and amputation must be resorted to for its relief.

In cases where the spermatic vessels are affected it would be interesting to try palliative measures first, such as the use of hypertonic salines, etc. Hemi-castration could always be resorted to as a last resource in cases where gangrene of the testis occurs.

SUMMARY.

1. The features of thrombo-angiitis obliterans affecting vessels other than those of the limbs are unknown.

2. A case is presented where the affected vessels were those of the spermatic cord.

3. The clinical appearances are almost exactly those of tuberculous epididymitis, but on analysis a few points arise which assist the differentiation. These are (*a*) local and radiating pains, and (*b*) a considerable apparent thickening of the *upper* part of the vas.

4. The histological changes found in the spermatic vessels of this case are those of thrombo-angiitis obliterans.

5. The whole sequence of events has been traced, step by step, from the first acute manifestation, through all intermediate stages, to the final healed product. These, in the order in which they occur, are: acute inflammatory infiltration of the coats of the vessels and surrounding supporting tissues, occlusive thrombosis, the formation of purulent foci in the peripheral part of the clot, replacement of the leucocytic areas by giant-cell foci, and, finally, organization and canalization of the obturating mass, associated with matting together of neighbouring arteries, veins, and nerves by inflammatory fibrosis.

6. The histological findings support the view, held by Buerger, that thrombo-angiitis obliterans begins in the form of an acute inflammation, the causal agent of which has as yet not been found.

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THE DEVELOPMENT OF CYSTS IN CONNECTION WITH THE SEMILUNAR CARTILAGES.

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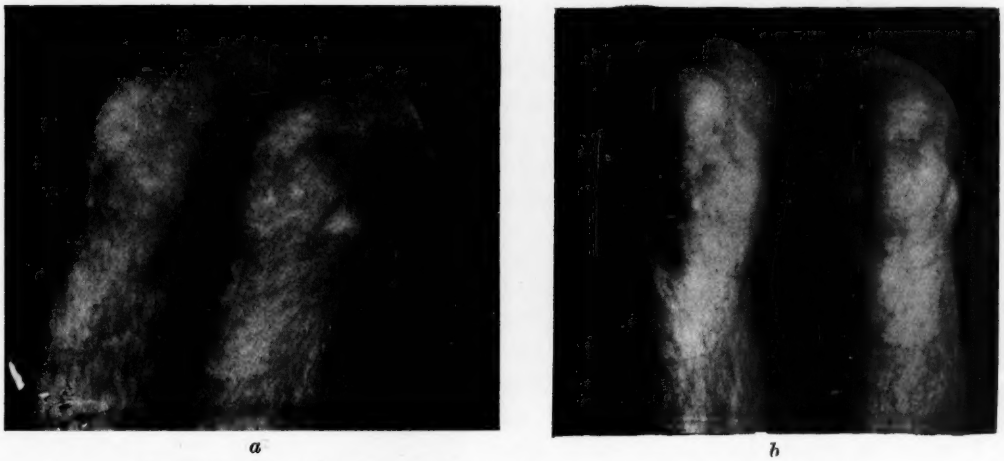
In 1921 I described in the British Journal of Surgery[1] three cases upon which I had operated because of persistent pain in the knee associated with a cystic change in the external semilunar cartilage. These were the first instances of the condition recorded in this country, although four cases had already been described in the German literature.[2–5] Since 1921 I have met with eighteen additional cases in my own practice, and, in the light of this unique experience, I propose to review my original description of the condition and its pathology. A number of isolated cases have been reported in American and British journals, but as these are readily available to everyone, and as no fresh points have been brought out by them, they will not be discussed.

In my former paper I referred to the fact that the cysts were found in the external cartilage, and up to that time my own (three) cases and all those reported in Germany had been on that side of the joint (*Figs.* 420, 421). In



a *b*

Figs. 420, 421.—*Case* 20. Typical appearance of cyst of external cartilage.
(*a*) Lateral view. (*b*) Anterior view.

my present series four out of the eighteen have occurred in the internal cartilage, so that, although the lesion presents itself chiefly in the external cartilage (seventeen times out ot twenty-one in my own cases), it may be found in the internal cartilage also. The pathology of the lesion has received

considerable attention, and a number of observers have challenged the statement that the cysts are lined by endothelial cells. Several other surgeons have found the lining as described and have confirmed my views. Many sections have been cut from my specimens, and, although we have not been able in every case to demonstrate the endothelium, we have no doubt at all that in most specimens the lining is clearly present (*Figs.* 422–427). Professor J. Shaw Dunn, of the Pathological Department of Manchester University, allows me to say that he is in entire agreement with this statement.

FIG. 422.—*Case* 11. Low-power view of typical section, showing septa between cysts.

Kleinberg[6] has published a report of one case of cyst in the external cartilage. In his report he mentions a case of Allison and O'Connor,[7] who recorded three cases, and gives their conclusion: that "it is our belief that these cysts represent the end-result of a degenerative process caused by an interference with the blood-supply of the cartilage in this region, the exciting cause of which is a non-lacerating injury." Kleinberg gives a description of his own case which falls in very well with the usual account. The specimen is then reported upon by Goldzieher, who states: "the larger cysts, which can be seen grossly, are formed by fibrous tissue. Their inner surface is lined by a layer of flat cells resembling endothelial cells and probably arising from the lymph vessels. The nuclei are rod-shaped and the cytoplasm is scanty. Some of these cysts are separated from each other by septa which consist of a few connective-tissue fibres covered on both sides by the endothelium described above. It seems fair to assume that the larger cysts arose from the vacuoles in the cartilage, and the formation of an endothelial lining, as well as that of a connective-tissue wall, are only secondary." *Fig.* 422 shows the septa separating the cysts.

FIG. 423.—*Case* 7.
High-power view of cyst lining.

Bristow[8] records eleven cases of his own and states that thirty cases are on record. He has found, in some of his specimens, what appears to be an endothelial lining to the cysts, but refuses to class the lining cells as definitely endothelial. In the same publication McMurray[9] makes the

dogmatic statement that the lining wall of the cysts 'has been shown' to consist of compressed cartilage cells.

The condition is, without doubt, a primary lesion of the cartilage. In nearly all cases there is a more or less definite history of an injury. In my opinion, following this injury pre-existing small spaces in the cartilage gradually

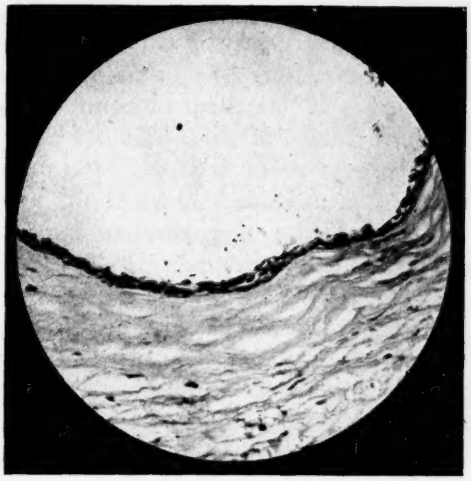


FIG. 424.—*Case* 11.

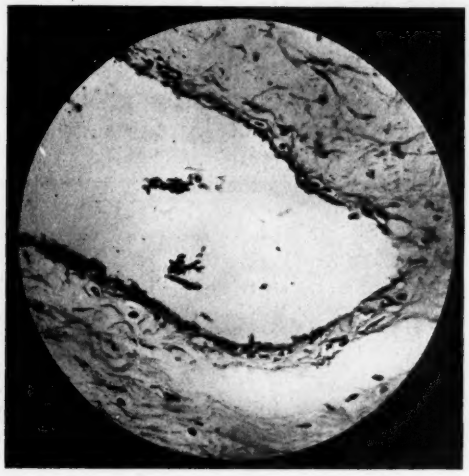


FIG. 425.—*Case* 4.

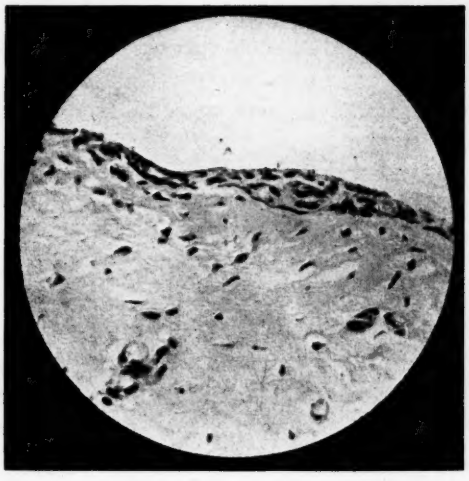


FIG. 426.—*Case* 20.

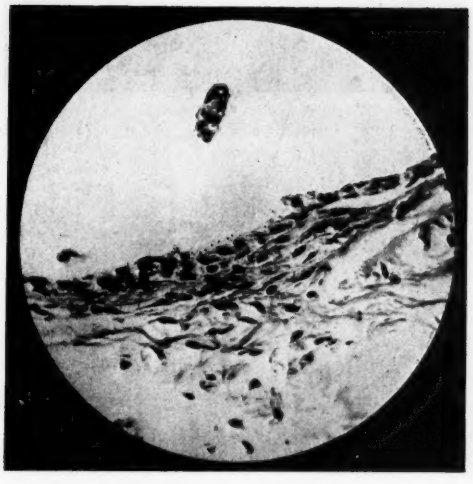


FIG. 427.—*Case* 15.

FIGS. 424–427.—High-power views of cyst lining.

enlarge, forming multiple cysts which are lined by an endothelial type of cell. In some sections, where no endothelium could be found, I believe that it had been detached in the preparation of the specimens. It is a very delicate layer, and, in cutting sections of a tissue containing material of such differing consistencies as fibrocartilage and the soft gelatinous content of the cystic

spaces, it is extremely easy to detach the lining cells. This is especially applicable to the larger cysts, where, I suspect, some have looked for the endothelial lining, neglecting the smaller spaces. In the sections which are here published there are, in my view, lining cells which cannot possibly be classed as anything but endothelium (*Figs.* 423–427). They are certainly not in the least like connective-tissue cells flattened out under pressure. The view expressed by Goldzieher that the endothelium is derived from the lymphatics is an interesting one. In my original paper I advanced the opinion that the cysts were of developmental origin, and this is accepted by Zadek and Jaffe,[10] who give a most detailed and excellent account of a specimen removed by them at the New York Hospital for Joint Diseases. Their observations regarding the presence of a definite endothelium, particularly lining the smaller spaces, agree with my own.

FIG. 428.—*Case* 8. Papillary synovial inclusions without distension of cysts.

Factors which favour the congenital theory are: (1) The multiplicity of the cysts; (2) The presence of papillary synovial inclusions without cyst formation (*Fig.* 428); (3) The absence of old or recent hæmorrhage into the cysts whether they are of old-standing or of recent development. The presence of a synovial endothelial lining in the smaller and medium-sized cysts refutes the idea that the cysts are ganglionic in character.

Kleinberg is, of course, wrong when he says that the condition "practically never invades the internal meniscus". My own series gives four cases out of twenty-one in the inner side, and Bristow's series gives two cases out of eleven—an almost exactly similar proportion. Working on this ratio, eighteen cases in one hundred should be in the internal cartilage.

Treatment.—In this connection I have nothing further to add to my paper published in 1921, in which it was stated that total removal of the cartilage with its cysts was essential for bringing about a cure. Bristow has pointed out the necessity of preserving the capsule of the joint when the dissection of the cartilage and cysts is being made. This is extremely important, and if it is improperly done, will prevent the proper approximation of the capsule.

None of the cases recorded below have given any trouble in their progress after operation, and all have recovered full function. In two of the older patients (*Cases* 7, 19) the osteo-arthritic changes present at operation appear to be stationary.

Figs. 429–432 show the macroscopic appearance of the specimens after removal and section.

CASE REPORTS.

CASES REPORTED IN 1921.—

Case 1.—Male, age 40. Cyst of outer cartilage. Operated upon eighteen months previously because of pain and local swelling. Cyst alone removed. Swelling recurred after six months, and pain necessitated a second operation at which I removed the entire cartilage. Left knee.

Case 2.—Male, age 21. Cyst of outer cartilage. Removal of cartilage and cyst. Left knee.

Case 3.—Male, age 26. Cyst of outer cartilage. Removal of cartilage and cyst. Left knee.

CASES NOT PREVIOUSLY REPORTED.—

Case 4.—Male, age 22. Injury to right knee six months previously. Swelling the size of a cherry over outer cartilage. Cartilage and cyst removed. (*Figs.* 425, 429.)

Case 5.—Female, age 32. Hit by a truck on the outer side of the right knee a year before the appearance of a swelling. Pain for three months and a feeling of stiffness in the joint. Limitation of extension at 170°. Removal of cyst and cartilage.

Case 6.—Male, age 46. History of a fall and injury to right knee three years before the present swelling appeared. This has been noticed for five months. Pain on extension. Removal of outer cartilage and cyst.

Case 7.—Female, age 42. Three months' history of pain in the left knee, with the appearance of a swelling on the outer side soon after. The swelling is tensely fluctuant. There is evidence of early osteo-arthritis in both knees. Removal of cartilage and cyst. (*Figs.* 423, 430.)

FIG. 429.—*Case* 4.

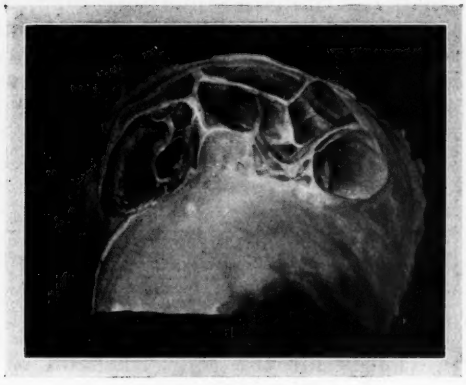


FIG. 430.—*Case* 7.

Case 8.—Male, age 30. Six months previously left knee injured at football. Tense cyst over external cartilage. Removal of cartilage and cyst. (*Fig.* 428.)

Case 9.—Male, age 22. Pain in joint, with local swelling over outer cartilage. Swelling is the size of a walnut. Injury at football six months previously. Removal of cartilage and cyst. This man is playing active football again and has had no further trouble with the knee.

Case 10.—Female, age 24. A blow on the left knee several months ago was followed by a swelling. Pain has been present, more or less continuously, for

three months. Swelling varies in size from time to time. Removal of outer cartilage and cyst.

Case 11.—Male, age 31. Right knee injured on active service. Pain and swelling over outer side. Removal of cartilage and cyst. (*Figs.* 422, 424.)

Case 12.—Male, age 10. Swelling over inner side of left knee for one year, said to have followed on a blow on the side of a desk at school. Painful at first, but less so now. Growing in size. Removal of cartilage and cyst. (This boy was shown to the British Orthopædic Association at Manchester in October, 1925, prior to operation.)

Case 13.—Female, age 28. Right knee twisted two years previously. Swelling on outer side of joint noticed about ten months ago. Tense fluctuant swelling. Removal of cartilage and cyst.

Case 14.—Male, age 6. No history of injury. Swelling over inner side of joint for several months; getting larger. Very little pain or tenderness on pressure. Removal of cyst only. Up to date (November, 1928) no sign of any recurrence. Operation was on Feb. 15, 1926. (*Fig.* 431.)

FIG. 431.—*Case* 14.

Case 15.—Male, age 20. Knee injured at work four months ago. Swelling over outer cartilage the size of a filbert. Removal of cyst and cartilage. (*Figs.* 427, 432.)

Case 16.—Male, age 23. Football injury with history of attacks of pain and swelling subsequently. Inner side of joint. Removal of internal cartilage and cyst.

Case 17.—Male, age 33. No history of injury. Swelling over inner side of left knee. Painful and cystic. Four months' history. Removal of cartilage (internal) and cyst.

Case 18.—Male, age 22. Right knee twisted at football six months ago. There is a cystic swelling over the outer cartilage which is loose enough to produce the well-known 'snap'. Excision of outer cartilage and cyst.

Case 19.—Male, age 54. History of several injuries in coal-mine. Right knee. Five months ago noticed a swelling over the outer side: painful. Cystic swelling. Knee moves through full range. Slight osteo-arthritis present. Removal of cartilage and cyst.

Case 20.—Male, age 19. Six months' history of pain in left knee. No very definite injury. Knee 'gives way' when walking. Swelling the size of walnut over outer cartilage. Removal of cartilage and cysts. (*Figs.* 420, 421, 426.)

Case 21.—Male, age 24. Seven months previously hit the right knee on a wagon. Since then has had pain in the outer side. Swelling over outer cartilage about half an inch in diameter, tender on pressure. Removal of cartilage and cysts.

FIG. 432.—*Case* 15.

SUMMARY OF TWENTY-ONE CASES.

Males	17
Females	4
External cartilage affected	17
Internal cartilage affected	4
Left knee affected	12
Right knee affected	9

CONCLUSIONS.

1. I report 18 additional cases of semilunar cartilage cyst; 14 in the external and 4 in the internal cartilage.

2. Cysts of the cartilages occur in either cartilage in the proportion of external 5·25 to internal 1.

3. They are by no means infrequent.

4. An associated history of injury occurs too frequently to be neglected as a cause.

5. Endothelial cells can in most cases be demonstrated lining one or more of the cysts.

6. The cysts are probably of developmental origin.

7. Prognosis, after removal of cyst and cartilage, is excellent.

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DEFORMITIES OF THE LUMBOSACRAL REGION OF THE SPINE.*

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SUMMARY OF CONTENTS.

I.—Anatomical Considerations.
II.—Radiographic Technique.
III.—Deformities due to Developmental Abnormalities
IV.—Spondylolisthesis.
V.—Deformities due to Injury.
VI.—Deformities due to Pathological Changes in the Bones and Joints.
VII.—Conclusions.

The radiographs of over three thousand patients attending several different types of hospitals have been studied during the past two years, and a clinical examination has been made of those patients whose radiographs showed any deformity of the lumbosacral area. In addition the lumbosacral area of forty post-mortem subjects has been investigated by dissection and X rays; and the specimens in the Museums of the Royal College of Surgeons and the University of Birmingham have been examined and photographed. To illustrate the cause of the deformities, radiographs of typical cases are used; photographs are employed to show characteristic features exhibited by deformed patients.

I. ANATOMICAL CONSIDERATIONS.

In the fœtus only the thoracic and sacral curves are present in the spinal column, but as the child assumes the erect posture, two secondary curves develop—the cervical and the lumbar. Normally until puberty, when standing erect, these primary and secondary curves pass almost imperceptibly into one another, preserving the balance of the trunk by concavity alternating with convexity.

The forward lumbar curve, which is more pronounced in the female than the male, begins at the middle of the last thoracic vertebra and ends at the anterior surface of the lumbosacral joint. This point, which in the erect posture is said to be vertically under the occipital condyles, marks the commencement of the sacral concavity—a concavity which faces downwards and forwards, and extends to the tip of the coccyx. As adult stature is reached,

* Paper awarded the Robert Jones Gold Medal and Prize of the British Orthopœdic Association for 1927.

the constant pressure of the weight of the trunk increases the sharpness of the lumbosacral angle. This weight is borne by the opposing surfaces of the vertebral bodies and their intervertebral discs anteriorly, and to a lesser extent by the articular processes posteriorly. In the healthy adult with a normally developed spine the curvatures are such as allow these surfaces to take the bulk of the downward pressure, and the erect posture is maintained by the tone of the musculature, without strain being placed upon the muscles and ligaments of the vertebral column. If, owing to ill health, the tone of the musculature is diminished, the weight causes an exaggeration of the normal curvatures and throws a strain upon the ligaments and articular surfaces. This is of course most marked at the lowest part of the trunk, where the flexible upper part articulates with the rigid extremity—that is, the lumbosacral joint. Similarly, if the bony structures of this area have a congenital weakness or their strength is diminished by any pathological process, the superincumbent weight will produce deformities of a nature dependent upon the position and extent of the weakness or lesion. Before considering abnormalities it will be well to describe briefly the chief distinctive characters in the normal anatomy of the lumbosacral area.

The 5th lumbar vertebra has several features which distinguish it from other lumbar vertebræ. Its body is slightly wedge-shaped, being deeper anteriorly than posteriorly. Its transverse processes are continuous with the anterior surface of the vertebral body, and in relation to the body lie on a more anterior plane than the transverse processes of the vertebræ above: they are usually shorter than the 3rd lumbar transverse processes. Professor Brash points out that there is a gradual increase in the size of the transverse processes of the lumbar vertebræ from the 1st to the 3rd; that the 4th are shorter, and the 5th usually a little longer than those of the 4th, and point upwards, outwards, and backwards. Professor Fawcett points out that the transverse processes of the 5th lumbar vertebra have two epiphyses—one for the costal element and one for the transverse element.

The spinous process is usually a little shorter, more pointed, and not so deep as the spinous processes of the other lumbar vertebræ, and its extremity is on practically the same plane as the inferior border of the vertebral body. The pedicles are broader, being strengthened by the continuation of the transverse process into the body. The superior articular surfaces are wider apart than those of the upper vertebræ. The inferior processes are about as wide as the superior processes. There is a great variation in the direction in which the articular surfaces face; in most cases the superior facets face backwards and slightly inwards, the inferior facets backwards and slightly outwards. The intervertebral disc of the lumbosacral joint is also wedge-shaped and thicker anteriorly than posteriorly, thus making allowance for the lumbo-sacral angle.

The five sacral vertebræ have fused together into a triangular-shaped mass. The costal elements are represented by the row of small tubercles on either side of the posterior surface. The spinous processes are smaller than those of the lumbar vertebræ. The laminæ of the lower vertebræ often fail to fuse and complete the neural arch. The sacrum has a concave anterior face which looks forwards and downwards. The superior articular facets usually face backwards and inwards, but these also show many variations.

The opposing surfaces of the 5th lumbar vertebra and the sacrum are joined together to form the lumbosacral joint by the following ligaments: (1) Intervertebral fibrocartilage, which also acts as a buffer between the vertebral bodies. (2) Anterior longitudinal ligament, which is attached to the intervertebral fibrocartilage and the edges of the vertebral bodies—the fibres, being of various lengths, joining two, three, or more vertebræ. (3) Posterior longitudinal ligament, which is attached to the posterior surfaces of the adjacent margins of the vertebral bodies. It is narrower opposite the bodies and therefore has a dentate appearance. (4) Articular ligaments and capsules. (5) Ligamenta flava—yellow elastic fibres which bind together the laminæ of the adjoining vertebræ and close the intervals between the laminæ; the fibres extend laterally as far as the articular capsules; medially they meet under cover of the root of the spinous processes. (6) Interspinous ligaments, which are obliquely interlacing fibres that pass from adjacent spinous processes from the tip of one to the base of the next. (7) Supraspinous ligaments—from the tip of one spinous process to the other. (8) Lateral lumbosacral ligament, which passes from the transverse process of the 5th lumbar to the base of the sacrum, expanding as it proceeds; some fibres are attached to the anterior sacro-iliac ligament. (9) Iliolumbar ligament from the tip of the transverse process of the 5th to the iliac crest. Some fibres from the 4th lumbar transverse process blend with the fibres from the 5th. The iliolumbar band proper is a thickening of the ventral layer of the lumbar fascia. (*Quain's Anatomy.*)

The psoas muscle passes over the antero-lateral aspect of the lumbosacral joint. The posterior relations are the intertransversarii, interspinales, multifidus, sacrospinalis, and the lumbodorsal fascia. The quadratus lumborum is attached to the transverse processes. In antero-lateral relation to the joint on each side is the lumbosacral trunk, which comprises the whole of the anterior division of the 5th and a part of that of the 4th lumbar nerve: it appears at the medial margin of the psoas major and descends over the pelvic brim and in front of the sacro-iliac joint to join the 1st sacral nerve. The last lumbar nerve emerges between the upper sacral articular process and the back of the intervertebral disc, and its posterior primary division turns back round the process to reach the postvertebral muscles, while its anterior part runs forwards, outwards, and downwards on the ala, being joined here by the branch from the 4th. Thus the nerve appears to emerge through an osseofibrous foramen completed externally by arching fibres of the iliolumbar ligament. All these structures are placed deep in the psoas. (Frazer.) Other structures in antero-lateral relation to the joint are the common iliac arteries and their bifurcations, the iliac veins, and the ureters. The pelvic colon and the mesocolon are also closely related to the left antero-lateral aspect.

The 5th lumbar nerve passes through an oblique bony canal which is directed forwards and outwards and is bounded in front by the postero-lateral surface of the body of the 5th lumbar vertebra, the posterior surface of the intervertebral disc, and the posterior surface of the upper part of the sacrum; laterally by the psoas muscle and some fibres of the iliolumbar ligament; and posteriorly by the anterior surface of the articular processes.

The importance of these joint relations to the nerve canal are emphasized in cases where the joints are involved in arthritic changes. Boniot and

Forestier state that the 4th and 5th bony nerve canals are long and that the nerve funiculus is not protected by an anatomical arachnoid sheath and is therefore influenced and irritated by variations in the rich venous plexus contained in the bony canal.

Causes of Lumbosacral Deformities. — The deformities of the lumbosacral region of the spine are due to: (1) Congenital abnormalities; (2) Injury; (3) Pathological processes involving the bones, ligaments, muscles, and nerves of the part; (4) Habitual faulty posture. The degree of deformity depends on the nature and extent of the lesion. It reveals itself to the examining surgeon as a faulty posture or gait; obliteration, exaggeration, or reverse of the normal antero-posterior spinal curvature; the production of a lateral curvature; the presence of a tumour; and the limitation of movements. The same type of deformity may have a widely different etiology, and even after a thorough clinical and X-ray investigation the true nature of the condition may not be determined. The clinical examination may indicate the nature of the lesion, but the bone and joint changes may not be of sufficient magnitude to show on a radiograph; sometimes a radiograph will show that the lesion is greater and more extensive than the clinical examination would lead one to suppose, and may throw much light on the etiology.

It is therefore the common practice of orthopædic surgeons to supplement their clinical examination by an X-ray investigation. For this reason it is considered advisable to give a few details of the necessary X-ray technique which the radiologist should observe.

II. RADIOGRAPHIC TECHNIQUE.

The radiographs should be of good quality, and should include both antero-posterior and lateral planes, while in some cases additional valuable help may be obtained from stereoscopic pictures taken with a transverse or longitudinal shift of the tube, and from radiographs taken in oblique planes, such as the plane of the lumbosacral joint —that is, with the central ray parallel with the inferior surface of the 5th lumbar vertebra, the tube pointing obliquely in the proximal direction with an angle of 40° from the vertical. *Fig.* 433 is an ordinary antero-posterior radiograph of the lumbosacral area. It shows an apparent crowding together of the 5th lumbar and 1st sacral vertebræ owing to a sharp lumbosacral angle. *Fig.* 434 is from the same patient taken with the central ray in the plane of the lumbosacral joint. It shows that these two vertebræ are normal

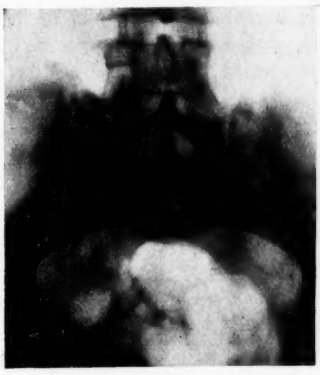


FIG. 433.

FIG. 434.

in shape and that the lumbosacral interspace is not diminished. Le Wald has pointed out that radiographs such as *Fig.* 433 have been interpreted as showing the condition of spondylolisthesis.

There is a temptation in hospital practice to be satisfied with only an antero-posterior radiograph if this does not show any obvious defect: this practice probably originated in the 'pre-Potter-Bucky and rapid film days', when it was difficult and in some cases impossible to obtain lateral radiographs. Even as late as 1925 Turner and Tchirkin stated in an article, " owing to difficulties in radiography we are unable to present a lateral radiograph of the spine."

The pictures should be taken with a tube giving the softest X rays consistent with the necessary penetration, so as to obtain the maximum of contrast in the radiograph; and the exposures should be as rapid as possible to eliminate the blurring effect of movement and the danger to the skin of the patient.

With children and thin patients the best-detailed pictures are obtained by rapid exposures to a soft gas tube on duplitized films between intensifying screens without the Potter-Bucky diaphragm, which separates the patients from the film by an interval and just robs the radiograph of its sharpness and fine detail; but for the average adult and stout patients the Potter-Bucky diaphragm is essential. A narrow cylindrical tube-box diaphragm will screen off other secondary rays and help to give a clearer picture.

III. DEFORMITIES DUE TO DEVELOPMENTAL ABNORMALITIES.

The variations in the development of the elements of the lumbosacral region of the vertebral column are very numerous, and I shall deal with their importance in producing deformity according to the position of the variation. The following anomalies were found :—

	Per cent
Spina bifida occulta—5th lumbar	6
Spina bifida occulta—1st and 2nd sacral.. ..	11
Sacralization of 5th lumbar—one side	3·4
Sacralization of 5th lumbar—two sides	4·7
Hemivertebræ	0·3

These figures may be compared with those of other workers. O'Reilly, who examined a large series of cases with anatomical variations, considers that 50 per cent of them showed symptoms of varying severity. Pugh, on the other hand, states that 85 per cent of the backs which he has examined showed some deformity, and he therefore concludes that the majority have no clinical significance. Rich examined 300 cases of painful back and found that 30 per cent showed some deformity or malposition of the 5th lumbar vertebra.

The Vertebral Body.—The bodies of the vertebræ develop from one centre of ossification, which appears at about the fifteenth week. An epiphysis for the superior and inferior surface appears about puberty and unites with the main body at about the twenty-eighth year. In some cases the centres appear which develop into hemivertebræ and do not fuse, thus giving the X-ray appearance of a split body. This is shown in *Fig.* 435, which illustrates a congenital 'split' of the 12th dorsal vertebra with some separation of the two halves. This appearance should not be mistaken for fracture.

In other cases only one of the two lateral centres develops. This may remain as a separate unit or it may fuse with the elements above or below; but whereas the 'split' body does not give rise to any deformity, as a rule the lateral hemivertebræ produce a lateral curvature. We have seen that the normal spine forms a series of antero-posterior curves, but with this asymmetrical growth the mechanics of the balance of the erect posture will be altered and a compensating lateral curvature must be formed. This cannot occur without a rotation of the other vertebræ, as was demonstrated by Lovett, who showed that a flexible straight rod could be readily bent in either an antero-posterior or a lateral direction—whereas a curved rod could only be bent in another plane if the rod underwent some rotation.

FIG. 435.

Fig. 436 shows the scoliotic deformity produced by a hemivertebra of the 1st sacral segment and an irregular development of the left pedicle and inferior articular processes of the 3rd lumbar vertebra and the superior articular processes of the 4th lumbar vertebra, which give the appearance of a fracture of the 4th vertebral body. Professor Dwight also mentions a case of an extra half segment in the sacrum. Professor Brash suggests that in the case of hemivertebræ the body condition is secondary to the nerve abnormality.

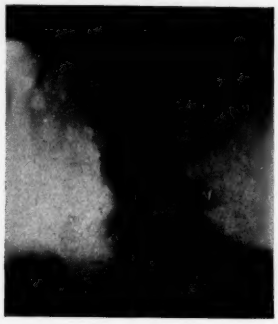


FIG. 436.

There is a specimen (No. 322) in the Museum of the Royal College of Surgeons, of the lumbar spine and sacrum of a child, age 12, in which the 5th lumbar is represented by a right-sided hemivertebra, and the alæ of the 1st and 2nd sacral vertebræ are poorly developed. This has caused a very marked angular curvature of the sacrum to the left, which is at right angles to the lumbar vertebræ. The laminæ of the vertebræ from the 3rd lumbar to the extremity of the sacrum have not fused and their extremities are wide apart, indicating an extensive spina bifida as well. This specimen is described by Parker in the *Transactions of the Clinical Society*, 1885.

FIG. 437.

FIG. 438.

In some cases two vertebral bodies fuse together, but as a rule these are only discovered by accident when the spine is X-rayed for some other condition. This happened in the case of the patient whose radiographs are shown in *Figs.* 437 and 438.

What appears on a radiograph as an almost shapeless mass may develop instead of the normal lumbar vertebræ. *Figs.* 439–442 illustrate the abnormal ossification of the lumbar spine of a male child, age nearly 5 years. The normal spine appears to cease at the 1st lumbar, after which three or four shapeless bodies are seen, with no attempt at neural-arch formation. The sacrum is represented by a small shapeless structure between the iliac bones. The child shows a marked kyphosis of the lumbar area and deformities of the lower extremities, including talipes and webbing of the knees and toes; there is also incontinence. There is no external appearance of spina bifida. Bowman quotes a case of a boy, age 6, without a sacrum or coccyx.

FIG. 439.

FIG. 440.

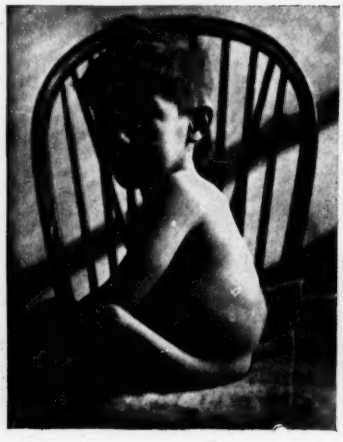


FIG. 441.

FIG. 442.

The Articular Processes. — The articular facets are developed from the ossification centres of the neural arch—one on either side of the body. Rambaud and Renault are of the opinion that the arch has two primary centres on each side and the two parts in each half are united by a plate of cartilage set obliquely between the superior and inferior articular processes. This may explain those examples of 5th lumbar vertebræ which have a separate neural arch comprising the spinous process, laminæ, and the inferior articular processes which are united during life by synchondroses. No suggestion of this type of deformity may be obtained from the radiograph.

There is a specimen in the Royal College of Surgeons Museum which shows a well-developed neural arch, including thick laminæ and normal-sized inferior articular processes and spine of the 4th lumbar vertebra, as a separate unit, and not fused with the remainder of the vertebra.

Figs. 443 and 532 show such a deformity of the 5th lumbar vertebra, and

Figs. 444 and 445 are radiographs of the vertebra shown in *Fig.* 443, with the units attached by soft wax, and demonstrate that even with the dried specimen the radiographs give no evidence that the laminæ have failed to fuse. They also show that the two parts are fully developed.

The articular facets of the lumbosacral joints show great variation in their shape and in the plane of the articular surfaces. The superior articular facets on the majority of sacrums are slightly crescentic and face backwards and slightly inwards. If the greater part of the facet faces backwards, no idea of the condition of the surface of the joint can be obtained from a radiograph; but if the greater part faces inwards, then the joint surfaces with a narrow space between them can be seen on the radiograph and any irregularity of the surface may be detected. In some cases one facet faces backwards and the other inwards—what Putti describes as 'anomaly of articular tropism'. As a general rule the surfaces are vertical, but this is not always the case. A careful examination of all the radiographs of more than three thousand patients suggests that 57 per cent face backwards, 12 per cent inwards, and 31 per cent are mixed—that is, one side may face backwards and the other inwards; one may be vertical, the other oblique.

FIG. 443.—Fifth lumbar vertebra in which the arch and the body have not fused.

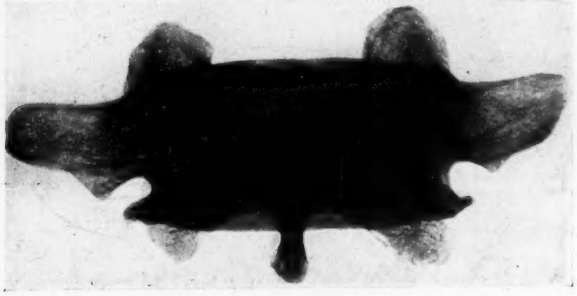


FIG. 444.—Antero-posterior radiograph of same specimen, with the arch and body united with wax. (Note that the non-union does not show.)

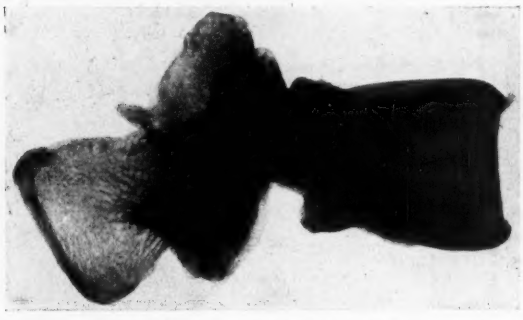


FIG. 445.— Lateral radiograph of same specimen, which shows no evidence of non-union of the neural arch and body.

In some cases the surfaces are quite flat and face directly backwards (*see Figs.* 451 and 453); this is said to be the rule in 'native races'. Most authorities are agreed that with an asymmetrical development of the articular processes, abnormal movements occur. Obviously the flat type only gives stability in one plane, so that any force directed in another plane will strain the ligaments of the joint. Separation of the neural arch with the inferior

articular processes may lead to a forward dislocation of the lumbar spine on the sacrum—spondylolisthesis.

Willis found a separate neural arch in 31 out of 748 cases which he examined: in 23 it was bilateral; the right half was involved in every case; 30 were males, 1 was a female; 28 were white, 3 were negroes. Von Lackum studied 30 bodies to determine if any anatomical instability was present in the lumbosacral area to account for the prevalence of low back pain. He found that in only 6 were the articulations of the lumbosacral joint symmetrical: 18 were grossly asymmetrical.

In only three of the cases in my series was a clinical deformity explained solely by an abnormal development of the articular surfaces. In these case the superior articular facets were small and irregular, while the inferior facets and laminæ of the vertebra above showed abnormal development, which resulted in scoliosis (*Figs.* 446 and 447). *Fig.* 446 is the spine of a woman, age 35, who complains of pain round the lower right ribs and lower spine, which is of a constant aching character, worse when lying down or sitting than when standing. The radiograph shows a congenital deformity of the right side of the 4th and 5th lumbar vertebræ and 1st sacral articular processes, which has produced a scoliosis.

FIG. 446.

FIG. 447.

FIGS. 448, 449.—Showing asymmetrical facets of the lumbosacral joint.

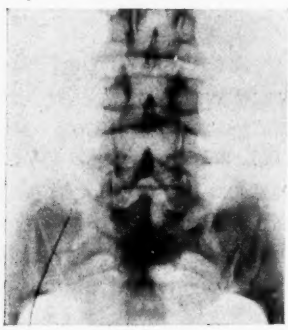


FIG. 450.—Showing symmetrical facets of the lumbosacral joint.

Asymmetry of the articular facets may be due to any lesion producing scoliosis (*see Figs.* 446–450). In the case shown in *Fig.* 448 this asymmetry is associated with sclerosis of the bone surrounding the facets and the base of

the pedicle. It was due to atrophy of the left lower extremity following anterior poliomyelitis. *Figs.* 451–454, from photographs of actual specimens, may also be studied in this connection.

FIG. 451.—Sacrum with flat articular facets.

FIG. 452.—Sacrum with asymmetrical crescentic facets.

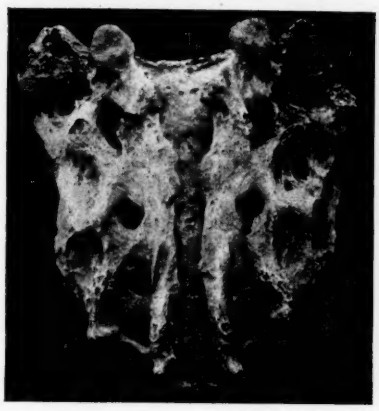


FIG. 453.—Posterior view of same specimen as *Fig.* 451. Note the flat articular processes and that the laminæ of the sacrum have not met, and the canal is left open.

FIG. 454.—Posterior view of same specimen as *Fig.* 452. Note asymmetry of articular facets.

Defects in the Neural Arch.—The centres of ossification for the neural arch are present at birth and fuse together during the first year, and about the sixth year they fuse with the body of the vertebra. In the radiographs of the 3000 patients examined, defects in the neural arch of the 5th lumbar vertebra were shown in 6 per cent, and in the 1st and 2nd sacral in 11 per cent. The degree of defect varied. The patients presenting an obvious tumour associated with spina bifida were not radiographed as a rule. In some the neural arches of the lumbosacral area were represented by small tubercles, but the majority only showed a split between the posterior extremities of both sides, one or other side often having a bulbous extremity—representing that no bone union had occurred. This non-fusion of the laminæ often gives an appearance suggestive of fracture—indeed, several of the cases had previously been reported as fracture of the laminæ.

Sutherland found a failure of fusion of the 5th lumbar or 1st sacral in 5 per cent (1st or 2nd sacral 70 per cent, 5th lumbar 24·5 per cent). Baetjer found a failure of fusion of the 5th lumbar in 15 per cent, Wentworth in

8·1 per cent, and Willis in 4·28 per cent. The last-named described seven types of defect; some of these occurred singly, others showed several of the defects (*Fig.* 455).

Decker describes a 6th lumbar vertebra with a spine which is split into two unequal portions and an articular surface between. The left portion is shorter (1·2 cm. long), more or less pointed, and is attached to the lamina (1·5 cm. broad), and with the lamina is directed backwards and outwards so as to be slightly concave laterally. The right portion embraces most of the spine, is club-shaped, and is attached to the lamina (1·6 cm. broad), which is directed almost horizontally outward. Another defect in the neural arch occurs in the right pedicle just behind and below the superior articular process, where there is a narrow triangular articulation, 2·3 cm. by 0·6 cm. long, looking upwards and slightly forwards. The separation of the pedicles is not complete, however, for below this joint, between it and the inferior articular process, there is definite bony continuity.

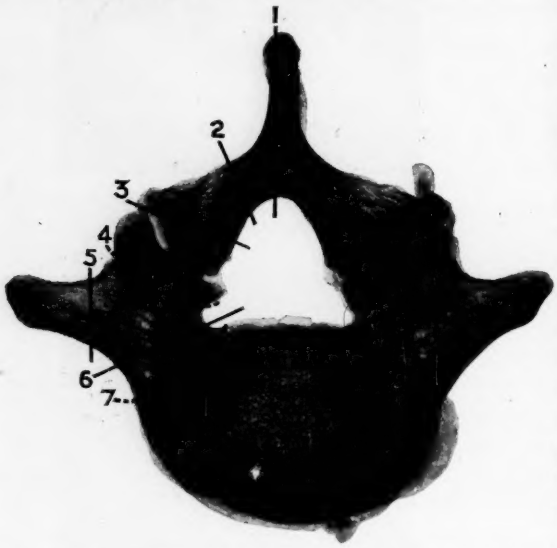


FIG. 455.—Showing the seven lines of non-fusion found by Willis in the examination of 748 spines.

Spina Bifida.—Five different types of spina bifida are met with:—

1. *The Myelocele*, in which the central canal of the cord is exposed, and the bone elements of the neural arch are represented by small nodules on either side of the posterior surface of the body. This type is usually located in the dorsi-lumbar area and is not compatible with life. It may extend along the whole spine.

2. *The Syringomyelocele*, in which there is a dilatation of the central canal with stunted development of the laminæ. In this type there is a tumour of variable size, and cord symptoms are present—paralysis of the lower extremities and incontinence.

3. *The Meningomyelocele*, in which there is a dilatation of the meninges of the cord through which the fibres of the corda equina pass. This is a very common type and is usually accompanied by paralysis of the lower extremities and incontinence, sometimes by rigidity and contractions.

4. *The Meningocele*, which is a dilatation of the meninges, and contains only the cerebrospinal fluid and no nerve elements; the common site is the lumbosacral region of the spine. Usually four or five of the neural arches are stunted. The cystic swelling may be as large as the child's head or quite small. It may be tense or flaccid, and the hole communicating between the cystic dilatation and the meninges may be very small. This and the preceding types are often associated with hydrocephalus. Operative measures applied to the

cystic swelling may be followed by the production of hydrocephalus. The symptoms may be slight, such as weakness of the lower extremities and sphincters, but may on occasion be severe. Whitehead records a spina bifida in an adult female which, from birth to the age of 21, was associated with a meningocele about the size of an egg, but gave rise to no symptoms. At this time the patient's circumstances compelled her to do hard manual labour and the tumour increased to the dimensions of 22 inches in circumference, and concomitant with the increase in size she commenced to have severe headaches, nausea and vomiting, attacks of vertigo, and transient moments of defective vision whenever the tumour was subjected to pressure, even that of clothing. The tumour was aspirated, cauterized, and after severe inflammatory changes finally healed, and the patient made a complete recovery.

5. *Spina Bifida Occulta*, which is the commonest type. In this condition there is a failure in the development of the neural arch of several vertebræ—usually in the lumbosacral area. The only physical sign may be a small lipoma, or a tuft of hair, or a dimple in the skin. There may be no symptoms, but some cases show progressive deformities of the lower limbs, talipes equinus, pes cavus, or instability of the lumbosacral region with low back pain, or pain from pressure on the nerve trunks. Operative measures for removal of the cystic swelling or other abnormality may not influence the chief symptoms due to nerve abnormality, which may be in the same developmental segment and consequently at a much higher level in the adult cord. These developmental errors are usually symmetrical, but some cases show definite asymmetry. Mr. Fitzmaurice Kelly recently showed a case of a female child, age 4 years 4 months, in which the lateral mass of the sacrum and the 5th lumbar were missing, and a cystic mass was situated under the gluteus maximus. The child had severe paralytic talipes of both feet and incontinence of urine.

Particulars of a specimen of spina bifida associated with hemivertebra are given on page 567. *Figs.* 456–459 show different types of non-fusion of the

FIG. 456.
Symmetrical laminæ.

FIG. 457.
Asymmetrical laminæ.

FIG. 458.
Asymmetrical laminæ.

laminæ. *Figs.* 460 and 461, which are taken from a girl, age 7, show an extensive spina bifida from the 3rd lumbar to the extremity of the sacrum.

The lateral radiograph shows large articular processes of the 3rd lumbar. The patient exhibited no external evidence of spina bifida. A 'knuckle' kyphos was present, which was thought to be due to caries of the spine.

FIG. 459.—Symmetrical laminæ with separate spinous process of 1st sacral.

FIGS. 460, 461.—Spina bifida extending from 3rd lumbar to the extremity of the sacrum.

Fig. 462 is the photograph of an external tumour in a man of 57. Radiographs showed only a faulty development of the 3rd sacral vertebra.

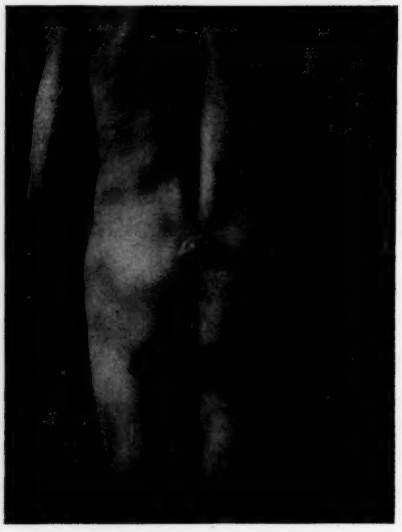


FIG. 462.

Spinous Processes.—The spinous processes are formed by fusion of the two sides of the laminæ, which takes place in the first year, and their development is completed by the growth of an epiphysis which appears about the sixteenth year and fuses with the main mass in the twenty-fifth year. In some cases, where the laminæ fail to fuse, the epiphysis for the spinous process remains as a separate bone and can be seen on many radiographs of the lumbosacral area (*see Fig.* 459).

The spinous process of the 5th lumbar shows variation in shape, size, and position. Sometimes it is flattened, drawn out, and, instead of being shorter than the spinous process of the 4th, it may be longer, as in the cases of spondylolisthesis. It may be united only to one side of the neural arch, or may be represented by the posterior extremities of the laminæ which have come together but not fused (*see Figs.* 456–459). It may be directly in the mid-line or be directed to one side. If for any reason the lordosis of the lumbar spine is increased, or the lumbosacral angle is diminished, the spinous processes are approximated to one another, until in some cases they touch each other, and their opposing surfaces may be moulded or faceted. Obviously, with such a spine, extension is checked by the locked-home position of the spinous processes, which are subjected to an abnormal strain, and bursa and arthritic changes readily

develop (*see Fig.* 539). Such patients have pain in the back when standing erect, which is relieved by bending forward.

Transverse Processes of the 5th Lumbar Vertebra.—There is no more variable part of the 5th lumbar vertebra than its transverse processes and no part in which developmental asymmetry produces deformity in so many cases. Bound up with the irregular development of these processes is the numerical variation of the vertebral column and sacralization of the 5th lumbar or lumbarization of the 1st sacral. Numerous observers have studied this question. The normal formula—cervical 7, dorsal 12, lumbar 5, sacral 5, and coccyx 4—varies in about 20 per cent of cases (Quain).

The cervical region is the most constant, while the most frequent site for the variation to be noticed is the lumbosacral. This is due to the marked difference in the characters of the free lumbar vertebræ and the fixed consolidated sacral vertebræ. Attention is drawn to the variation in the cervical area by the cervical 'rib' pressing upon the brachial plexus or some of its elements, or the vessels. In the lumbosacral area variation is common; in my series 3·4 per cent show sacral characters on one side and lumbar characters on the other. The variation in this area appears to be more frequently in the direction of elongation rather than shortening of the column, but the statistics of different observers show differences in this respect. It will be noticed as a rule that when the change of character is at the junction of one series of vertebræ with another, the next junction will show a change in the same direction—a sort of oscillation passing distally or proximally.

In the case recorded by Professor Brash with the formula C6½, T13, L5, S5, C4, there was no evidence of the 5th lumbar vertebra having been derived from the sacrum. Failure of the 1st sacral segment to fuse with the other bodies may suggest a 6th lumbar (*see Fig.* 433). Six lumbar vertebræ is a common X-ray finding. Bardeen, after a study of reports of 1059 specimens including 75 of his own, found that numerical variations occur in about 16 per cent of vertebral columns, of which 7·5 per cent have compensated variations and 8·7 per cent uncompensated, equally divided between increase and decrease of segments. He says that there is no evidence that intercalation of a whole vertebra occurs.

Side by side with these oscillations in the vertebral characters, variations are seen in the constitution of the lumbosacral plexus. Eisler records concomitant variations in the plexus of 18 per cent of the cases. They occur within wide limits, as shown by the following table of extreme cases.

	Pre-fixed Variety	Normal	Post-fixed Variety
Nervus furcalis ..	L3 & 4 (double)	L4	L5
Obturator	L1, 2, 3 ..	L2, 3, 4 ..	L2, 3, 4, 5
Femoral	T12, L1, 2, 3, 4	L2, 3, 4 ..	L2, 3, 4, 5
Tibial	L3, 4, 5, S1, 2	L4, 5, S1, 2, 3	L5, S1, 2, 3, 4
Common peroneal..	L3, 4, 5, S1	L4, 5, S1, 2	L5, S1, 2, 3

The transverse process is developed from the centre of ossification for the neural arch, but at the sixteenth year an epiphysis appears (sometimes

two, Fawcett) which fuses with the main process about the age of twenty-five. We have seen that the costal rudiments of the 5th lumbar extend over the pedicles to the sides of the body, whereas in the sacrum they enlarge and form the alæ on each side—the transverse processes only being represented by nodules on the posterior surface. A foramen has been observed in the 5th lumbar transverse process by Szawlowski and Dwight which marks the costal from the true transverse element—the anterior part of the transverse process being the homologue of a rib; the true transverse element is represented by the posterior part of its root, including the accessory process. When the transverse processes are large they may articulate with the sacrum—the lumbosacral transverse articulation of Dwight—but in some cases the processes grow out in a direct lateral line and articulate with the ilium.

There are marked differences to be seen in the breadth of the sacrum and the height at which it articulates with the ilium, apart from sexual differences. *Fig.* 463 shows the sacrum with its superior border almost on the same plane as the iliac crests: a line joining the latter would pass through the 5th lumbar vertebra. The straight and long transverse processes of the 5th lumbar should be noted. *Fig.* 464, on the other hand, shows a low sacrum with the ilium on both sides rising up to the height of the 3rd lumbar vertebra. The transverse processes of the 5th lumbar are short and turned upwards — the sacrum is narrow. The radiographs were taken in the same relative positions. The high type of sacrum is regarded by some authorities as unsound architecturally as it is not so well supported by the sacro-iliac and spinal muscles and ligaments, but radiographically it appears more sound; the lumbosacral angle is a gentle curve extending over several vertebræ. The same condition is seen with complete symmetrical sacralization of the 5th lumbar.

FIG. 463.

FIG. 464.

Moore is of the opinion that anatomically and architecturally the sacralized formation appears stronger and more able to resist strain than the usual arrangement. Von Lackum suggests that surgical measures to fuse the 5th lumbar with the sacrum would be better than removing interfering masses. While this is so with symmetrical sacralization, with asymmetrical development of the 5th lumbar processes curvature and rotation of the lumbar vertebræ is produced which in time is followed by compensating curvature of the dorsal vertebræ in the attempt to preserve the balance of the erect posture. The vertebræ in their normal positions are so constructed that they can withstand the strain of normal movements and postures, but in the positions which they occupy as the result of the curvature they are placed at a disadvantage and cannot resist the strain put upon them. The curvature therefore tends to increase.

Figs. 465 and 466 are photographs of the anterior and posterior surfaces of a specimen of unilateral 'lumbarization'. It will be seen that the lower four segments have fused to form the body of the sacrum. The upper segment shows sacral characters on the left side and lumbar characters on the right. The joint space between this segment and the main sacral body is

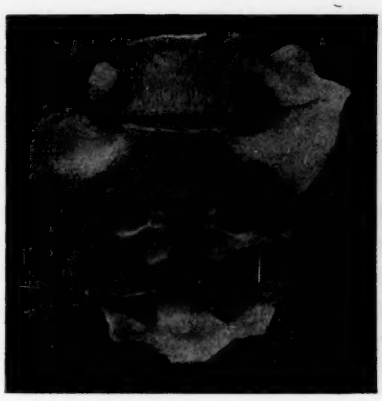


FIG. 465.—Anterior view.

FIG. 466.—Posterior view.

almost obliterated, the angle between them is 154°. The right transverse process resembles that of a normal 5th lumbar vertebra and is directed backwards and outwards; the left transverse process is higher than the right and extends further back, but its pedicle is greatly thickened on a more anterior plane ($\frac{1}{4}$ in.) and is continued forward by its costal element to articulate with the ala of the sacrum. The intervertebral canal on the left side is therefore longer and narrower; it is narrowed even more by the 'lipping' which has occurred at the transverse 'lumbosacral' joint. The body is wedge-shaped in two directions, being deeper on the anterior and the left sides, and is twisted to the left. Its upper border is oblique and the articular facet is on a higher plane on the left. This marks the beginning of a scoliosis, as illustrated in *Figs.* 467 and 468. It will be noticed in *Fig.* 466 that the neural arch of the upper segment has not fused, the right side being longer than the left and forming the spinous process, which is deviated to the left. The right superior facet of the fused body of the sacrum is normally developed, but the left is smaller and is continued proximally into an irregular process which is

FIGS. 467, 468.—Illustrate the beginning of a scoliosis produced by unilateral 'sacralization' of the 5th lumbar vertebra.

partly fused with the poorly developed upper segment inferior articulation. The inferior articular processes of the upper segment are not so well developed or so far apart as the superior.

Figs. 469 and 470 show a bilateral 'sacralization' of the 5th lumbar vertebra in which the transverse processes have not developed symmetrically. The left is completely fused with the sacrum, the right has a definite joint surface with the sacrum. There is a fusion of the left side of the bodies by new bone which protrudes into the intervertebral foramen on that side. The body is only slightly twisted to the left. The neural arch, including the spinous process, inferior articular processes, and lamina, is poorly developed and not fused with the superior articular processes or pedicles. The latter are continued distally as an irregular process to form an irregular joint with similar processes from the superior extremities of the superior articular facets of the sacrum, which are smaller and not so far apart as the superior facets of the 5th lumbar. The lumbosacral angle is 148°. The sacrum in this specimen is shown to consist of five bodies (cf. *Figs.* 471 and 472).

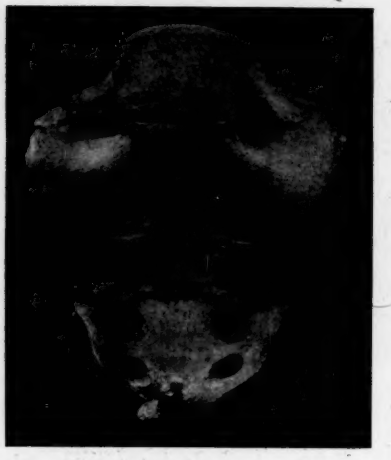


FIG. 469.

FIG. 470.

Figs. 471 and 472, which are photographs of a specimen from an Anglo-Saxon burial ground, show an asymmetrical 'lumbarization' of the upper sacral segment, only four segments being fused to form the main body of the sacrum. It shows similar features to the specimens already described (*see Figs.* 465, 466, 469, 470), but in this case the neural arch is fully developed. The spinous process is a little to the left of the middle line, the right lamina being a little longer than the left. The rotation of the body is less than in the preceding case. The intervertebral foramen on the right side, however, is not so deep as the left, which is again narrowed by the boss of new bone at the lumbosacral transverse joint. The inferior articular processes of the upper segment are not so well developed or so far apart as the superior. The lumbosacral angle is 140°.

It will be noted in all the specimens that asymmetrical sacralization leads to a scoliosis. These specimens have completely fused on the one side, but the presence of an articular surface on the other side, together with the new bone formation at the site of the fusion, suggests that in earlier life movement did occur at this joint which was somewhat restricted and strained by the asymmetry of development and a tendency to one-sided fusion.

These specimens lend some support to the paragraph in *Orthopædic Surgery* by Jones and Lovett, and in Cunningham's *Anatomy*, which states, "the presence of a lumbosacral transverse articulation combined with osteo-arthritis of the lumbosacral joint on the same side, may result in a reduction of the size of the intervertebral foramen which transmits the anterior division of the 5th lumbar nerve. Pressure on the nerve as it issues from this fibro-osseous foramen may account for the referred pain which is sometimes associated with these cases, whilst the branch of the 4th lumbar nerve which descends in front of the abnormal lumbosacral transverse articulation is also liable to be pressed upon." Usadel says that this suggestion is false. Putti supports the pressure-pain theory, but further states that "it must be borne in mind that the 4th lumbar contributes to the formation of the plexus, and it is often possible to demonstrate that the pain is due to involvement of this root and not the fifth, which alone could be affected by sacralization."

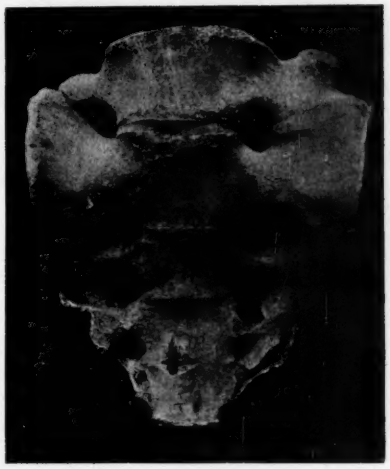


FIG. 471.

Baumen operated on twenty cases, in which he claims relief in practically all. He says: "In removing the deepest anterior part of a sacralized process there were distinct muscle twitchings, indicating the close proximity of a nerve cord (this has been observed several times), and as the last of the process was withdrawn, the nerve cord seemed to follow it up across the wound, until it occupied a position about one inch nearer the surface than it could have occupied before. This nerve cord must have been stretched tightly across the process and pressed upon by the process. The sciatic pain was relieved in this as in almost every one of the operated cases."

FIG. 472.

Aimes and Jaques, in 63 cases of persistent lumbar pain, noted 38 instances of sacralization of the 5th lumbar vertebra. Basset describes a case of a girl of 23 whose pain was permanently cured by a partial removal of the long transverse process of the 5th lumbar. *Figs.* 473 to 484 show different types of 5th lumbar transverse processes.

In my own series of cases 8·1 per cent showed sacralization of the 5th lumbar vertebra, 3·4 per cent being unilateral, 4·7 per cent bilateral. Many of these were discovered on the radiographs of patients complaining of symptoms suggestive of stone in the urinary tract for which they were X-rayed. There was no clinical evidence that the sacralization produced symptoms. In

a few cases, however, the patients complained of pain in the lumbosacral area, sometimes radiating down the back of the thigh, in which the only abnormality found was a sacralization. In one of these cases the patient had 'sciatica' with some atrophy of the gluteal muscles on the same side as the sacralization, which had produced a scoliosis. There seemed to be some

FIG. 473.—Dichotomous branching of the left 5th lumbar transverse process, the costal element of which is articulating with the ala of the sacrum.

FIG. 474.—Double fused transverse processes of 5th lumbar on both sides, with abnormal development of the other processes; also nonfusion of laminæ of 1st sacral.

FIG. 475.—A large left transverse process of 5th lumbar which is articulating with the ilium and sacrum. A lumbar curvature is associated with this abnormal development.

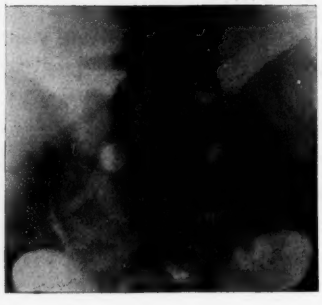


FIG. 476.—Asymmetrical sacralization of the 5th lumbar on both sides. The right side has partly fused. Note definite scoliosis.

FIG. 477.—Bilateral 'lumbarization' of 1st sacral vertebra with nonfusion of laminæ. (Cf. with *Fig.* 478).

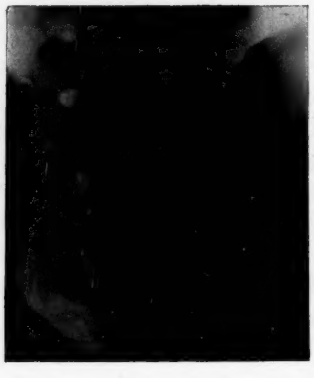


FIG. 478.—Bilateral sacralization of 5th lumbar. There appears to be an over-development of the costal element with suppression of transverse element.

relation between the production of pain and the age at which articulation with the process occurred.

Figs. 479–484 are a series of radiographs of different patients to show the stages in the development of the unilateral sacralization of the 5th lumbar processes.

In children the large costal element of the 5th lumbar vertebra which is taking on sacral characters is often shown on the radiograph as a separate

FIG. 479.—Sacralization of right transverse process of 5th lumbar.

FIG. 480.—Sacralization with marked scoliosis.

bone, which suggests that it has a separate centre of ossification. Gegenbaur has pointed out that the anterior part of the lateral mass of the 1st, 2nd, and 3rd sacral vertebræ is developed from a separate centre which represents the costal element (Fawcett). With unilateral sacralization there may or may not be scoliosis. If the lumbosacral transverse articulation is painful, the patient will list over to the opposite side and produce scoliosis. In those cases in which the 5th lumbar transverse processes are long and articulate with the ilium (*Fig.* 485), there may be no pain, but several cases which I have seen have complained of great pain over the articulation, and this has been the only bone abnormality to be seen on the radiograph to account for it.

FIG. 481.

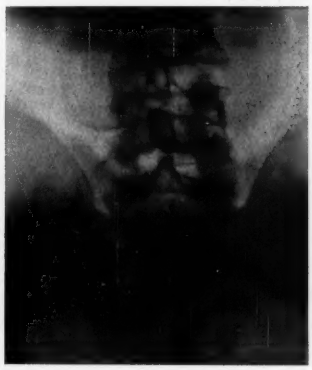


FIG. 482.

FIG. 483.

FIG. 484.

FIGS. 481-484.—Radiographs showing different stages of unilateral sacralization of the 5th lumbar transverse processes.

Verrall states that in his experience when symptoms do occur they consist-of intractable pain, both local and referred to the area supplied by the 4th lumbar nerve, as the junction between the 4th and 5th lumbar nerves

lies immediately anterior to the process. He approaches the process by cutting a window from the ilium and thus removes the opposing surface.

FIG. 485.—Articulation of the 5th lumbar transverse processes with the ilium.

With erosion of the sacro-iliac joint, the surfaces may slip and the normal transverse processes of the 5th lumbar vertebra on one side may be brought into contact with the ilium and be a cause of pain when the original lesion is consolidated. The transverse process may also be brought into relation with the ilium by a scoliosis due to infantile paralysis, hip-joint disease, or any other lesion producing a curvature (*Figs.* 486, 487).

There is no doubt that with all these irregular and asymmetrical joints, unusual strain is put upon the opposing surfaces; adventitious bursæ form and from time to time become inflamed and give rise to pain. Such surfaces frequently show osteo-arthritic changes when other joints appear to be normal. Ossification of the iliolumbar ligaments may occur (*Fig.* 488), and this is usually associated with pain. Of the five cases in my series, all complain of low back pain. In one case this was associated with pain in the gall-bladder area, which led to some difficulty in the diagnosis. An X-ray examination revealed calcification of the iliolumbar ligaments and a collection of gall-stones. Doub refers to twenty cases observed at the Henry Ford Hospital. He states that the calcified ligaments and transverse processes were removed in one case with complete recovery.

FIG. 486.—Articulation of right transverse process of 5th lumbar with ilium due to sacro-iliac disease and scoliosis.

FIG. 487.—Articulation of left transverse process with ilium due to old tubercle of left hip-joint.

FIG. 488.

Lumbosacral Angle.—Bardeen points out that in the embryo of 5 cm. (9 weeks) the sacrum is nearly straight and in a line with the lumbar region. From this time onward the lumbosacral angle begins to form. When a child begins to walk the lumbar curve is formed

and the sacral concavity becomes more marked and the lumbosacral angle more salient. In the adult the lumbosacral angle is on the average 120°, but this shows variations in both directions; in the labouring class chiefly in the reduction of the angle. In the series which I have examined, those spinal columns with a high sacrum or with symmetrical sacralization of the 5th lumbar showed the widest angle. In these cases it can hardly be called an angle at all; the lumbar vertebræ and inter-vertebral discs are so shaped that the forward curve is a gradual one and the change to the sacral concavity is spread over several vertebræ. The anterior surfaces of the last lumbar and upper sacral segments if produced make an angle which may be as great as 160°. Commonly in the female the 5th lumbar body appears to be a little more wedge-shaped, and its spinous processes appear a little smaller to accommodate the greater sacral convexity.

The body of the 5th lumbar and the lumbosacral intervertebral disc are thicker anteriorly than posteriorly, as a result of which the weight of the trunk exerts a shearing strain at this joint and tends to diminish the angle. The actions of stooping, bending, sitting, and standing all call for lumbar movement; in fact, most of the principal movements of the trunk occur in the lumbar spine, flexion being the most extensive and more free in that region.

Considerable discussion has been taking place on the subject of different muscle functions. It is held by some that there are two different muscle functions—that of postural tone and that of movement. The former, controlled by the autonomic system, should maintain the correct position without effort or fatigue. When it fails in its function owing to some general weakness the other function of voluntary muscular contraction may be called in to take its place. This quickly leads to fatigue and pain. With this fatigue there is an exaggeration of the normal curves. The lumbar lordosis is increased and the intervertebral joints are maintained at the limit of their motion. This strain is usually felt by all patients after a prolonged rest in bed. A similar sequence of events is produced by regular employment which necessitates lifting or carrying heavy weights or assuming a bent position. As a result of this long strain in the fully flexed or extended position, the bones undergo a degree of moulding and the ligaments are stretched until eventually the muscles cannot correct the deformity. The balance, which in the normal subject is so well adjusted, is upset and a gradual increase in the deformity results. Goldthwait distinguishes two well-known variations from the normal skeleton which are particularly liable to suffer from lumbosacral backache:—

1. The tall, slender, visceroptotic type with a long narrow flexible spine, who often assumes a faulty posture. In this type the articular facets are flattened and movement is free. The lumbar lordosis is exaggerated and the lumbosacral angle is diminished. This results in approximation of the spinous processes to one another and adventitious bursæ are found between them. Constant slight traumata inflame the bursæ and they become a source of pain.

2. The short, thick, heavy type in whom the diarthrodial facets are large and crescentic. These limit the movements of the vertebræ, particularly lateral flexion. If the facets are unequal, the movements are irregular. In this type the lumbosacral angle is strained.

Sudden unexpected blows directed to the trunk usually cause damage to

the ligaments, as the muscles are not on their guard and the joints are forced to the extreme limit of their excursion; the ligaments controlling the extent of the movement are strained or even ruptured. As the lumbosacral joint is the junction of the mobile and the fixed parts of the vertebral column, any such downward thrust on the upper part of the trunk, or the momentum of a fall in which the patient lands on the buttocks, will strain or rupture the ligaments of the joint. If the part is placed at rest until the ligaments are healed, little harm may result, but if there is a repetition of small degrees of trauma of this nature, the ligaments will be permanently altered, the lumbosacral angle will diminish, and arthritic changes will occur in the joints.

Herndon examined 498 cases of injuries to the back, 68 per cent of which he diagnosed as sprain, the most frequent site being in the lumbosacral region.

FIG. 489.

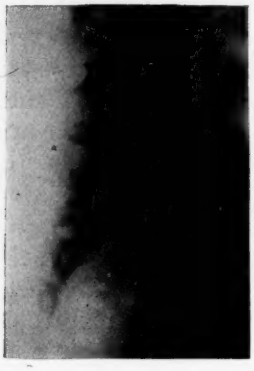


FIG. 490.

FIG. 491.

The symptoms in these cases were pain, tenderness, stiffness, and limitation of movement. An antero-posterior radiograph of this condition may show a tilting upwards of the spinous processes and an apparent crowding together of the vertebræ. This may be interpreted as a crushing or slipping forward of the vertebral bodies. A lateral radiograph will show that the appearance is due to a narrowing of the lumbosacral angle. A. Whitman has described five cases of this nature. They complained of pain in the back in the region of the lumbosacral joint; occasionally the pain radiated down the front and back of the thigh. The character of the pain varies from a sharp agonizing variety to chronic weakness and discomfort. He calls the condition a 'pre-spondylolisthesis'. Hibbs's fusion operation was performed in one case to prevent an increase of the deformity. *Figs.* 489–492 illustrate normal variations of the lumbosacral angle. *Figs.* 515 and 516 show the condition of pre-spondylolisthesis (*see* p. 598).

FIG. 492.

IV. SPONDYLOLISTHESIS.

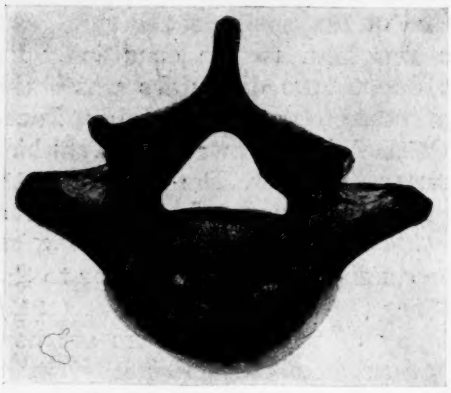
This is a term derived from the Greek word meaning 'gliding of a vertebra', and was first applied to the condition about to be described by Killian in 1852. The malady had been observed and described previously by Herbineau (1782), Rokitanski (1839), and Belloc (1849), but it was not until Neugebauer in 1892 published his description of 101 cases, for the most part museum specimens, that much attention was paid to the condition. Its chief importance, even at this time, was due to the difficulties which the deformity produced in obstetrics. Many other observers—notably Lane, Bowman, Darling, Lovett, Kleinberg, Balensweig, Turner and Tchirkin, Napier, Albee, Wideroe, Wiemens, Magnuson, Strasser, Barnes, Herrgott, Braun, Swartz, Spaeth, Roberts, Fitch, Palmer, and Lambl—published a series of cases.

All the earlier workers looked upon the condition as being peculiar to the female sex, but Codivilla (1908), Brandenburg (1910), and McCordick (1912) reported a similar deformity in males. Many of the later writers are now trying to make out that the condition is a very common one, and is much more common in males than females. Thus Bowman says it is a common cause of low back pain, while Sir Arbuthnot Lane goes so far as to say that spondylolisthesis is the normal condition in coal heavers. Further, each writer appears to crowd into his list of cases a number in which the evidence of spondylolisthesis is very doubtful. Thus Albee, referring to one of his eight cases, says, " It is questionable whether the case should be classified as spondylolisthesis ". Radiographically it is not, yet in his summary he says, " the author reports eight cases ".

Several base their diagnosis on the appearance of antero-posterior radiographs which, in my opinion, give no justification for such a diagnosis. Thus only one of the five sketches of the antero-posterior radiographs of Turner and Tchirkin shows the characteristic features illustrated by Jones and Lovett and Whitman. The other four sketches do not give any evidence of spondylolisthesis; further, they state that no lateral radiographs were made. This statement also appears in the same article: " As the condition generally develops in adults, the symptomatology is usually sufficiently striking to point to a correct diagnosis, although diagnostic errors have been made by Neugebauer and others." Herndon reported in 1927 that he had examined 941 patients suffering from back injuries, all but a few being coal miners, and found only two cases of spondylolisthesis.

After a careful examination of the radiographs of all the patients in my series of over three thousand, I have found only five definite cases of spondylolisthesis: three girls, ages 13, 15, and 17; a boy, age 17; and one man, age 35. In men I have found two cases in which the lumbosacral angle was much reduced—A. Whitman's 'pre-spondylolisthesis': one was due to a severe blow on the shoulder, the other to a fall of 16 feet (*see Figs.* 515 and 516). Yet many patients complained of low back pain, and had received injuries in mining and other heavy work; in fact, the series represents an examination of a large proportion of all the back injuries sustained in the factories and mines of a large industrial area, and several hundred soldiers who had had injuries

to the back from falls or crushes. These cases of spondylolisthesis came to my notice within a few days of each other, and but for the fact that I had been carefully looking for an example of this so-called common condition, I might have thought that I had missed many, and that, after all, it was common. Quite a number of the patients gave clinical signs suggestive of spondylolisthesis, but the antero-posterior and lateral radiographs failed to confirm the diagnosis.



FIGS. 493 and 494.

X-ray Appearances.—It will be well at this stage to describe the X-ray appearances of the deformity.

Antero-posterior Radiographs.—These may be absolutely typical. Such radiographs are illustrated in the orthopædic surgery text-books of Jones and Lovett (p. 342) and Whitman (p. 126). The antero-posterior radiographs of four of the cases referred to above, which are described later, show the same feature. The characteristic features of the radiographs of the 5th lumbar vertebra when X-rayed from above—that is, from its superior to its inferior surface—are shown by the radiograph of a disarticulated 5th lumbar vertebra (*Fig.* 493). It will be seen that the anterior border of the transverse process is continuous with the anterior border of the body. With a definite case of spondylolisthesis the superior surface of the body of the 5th lumbar vertebra is facing forwards, and an antero-posterior radiograph of the patient will show the 5th lumbar body and transverse processes in this plane, and this characteristic outline (*Fig.* 494) of the anterior border of the body and transverse processes will be projected against the shadow of the sacrum. These features are well shown in the radiographs of the authors mentioned, and in *Figs.* 495–498. When present such an appearance is indicative of spondylolisthesis. I have not seen any other condition which gives this appearance on an antero-posterior

FIG. 495.—Antero-posterior radiograph of Miss G. H., age 25, showing spondylolisthesis, and bone-grafts from the 3rd lumbar spine to the sacrum and ilium which were inserted in October, 1917.

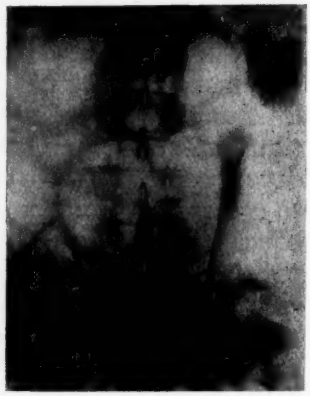


FIG. 496.—Radiograph of Mr. C., age 35, showing spondylolisthesis, and a catheter in the ureter through which the pelvis had been filled with sodium bromide solution. Note hydronephrosis and stones.

radiograph. Antero-posterior radiographs of patients having a sharp lumbo-sacral angle or 'lipping' of the anterior margins of the vertebral bodies of the 5th lumbar and 1st sacral have been interpreted as spondylolisthesis. Antero-posterior radiographs illustrating these two conditions are shown in *Figs.* 433 and 499. The latter shows a dark crescentic line (indicated by an arrow)

FIG. 497.—Antero-posterior radiograph of Miss J. F., age 13, showing spondylolisthesis.

FIG. 498.—Antero-posterior radiograph of Miss P. S., age 15, showing spondylolisthesis.

FIG. 499.—Showing a condition which may be mistaken for spondylolisthesis.

which is due to ossification of the ligaments of the anterior surface of the 5th lumbar and 1st sacral vertebræ with some 'lipping' of the opposing borders. (Note also that the laminæ of neither the 5th lumbar nor 1st sacral have fused, and a separate spinous process of the 1st sacral is shown.) The condition may be associated with massive new bone formation in front of the bodies, which may not only be misinterpreted owing to its radiographic appearances, but also owing to its appearance at post-mortem.

Lateral Radiographs.—The lateral radiograph furnishes us with almost absolute proof of the presence of any anterior 'slipping' of the 5th lumbar body on the sacrum. A good lateral radiograph will show the outlines of both these vertebræ. consequently the alinement of the anterior and posterior borders of the bodies can be seen. If a line is drawn connecting the anterior surfaces of these vertebræ, it will be seen to form a curve, the extent of the convexity depending on the lumbosacral angle, but if the 5th lumbar body has slipped forward on the sacrum, a definite break will be produced in the regularity of the curve. Further, if a straight-edge is placed along the shadow of the anterior border of the 1st sacral body, it will project upwards and forwards well to the front of the shadow of the 5th lumbar body, whereas if there is spondylolisthesis, the straight-edge will cut into the body of the 5th lumbar.

Bowman suggests that the alinement should be judged from the posterior surface of the bodies, but, as Le Wald has shown, the superior border of the 1st sacral laminæ may be mistaken for the superior border of the 1st sacral body, and an erroneous interpretation of spondylolisthesis is made. On the other hand, one may be misled by judging the alinement solely from the anterior border. In one case in my series, while the antero-posterior radiograph showed what I have described as the typical appearance of spondylolisthesis, the

lateral radiograph appeared to show that the anterior alinement was perfect. With a better radiograph the cause of this misinterpretation was apparent. The 5th lumbar vertebral body had slipped forward and its anterior border had been brought into alinement with the shadow of the lateral border of the sacrum, which was interpreted as the anterior border of the middle of the sacrum. In this case it was the antero-posterior radiograph which gave the clue to the diagnosis. The moral of this is that a diagnosis should only be made on good radiographs taken in the antero-posterior and lateral planes. Particularly is it necessary to correlate the appearances shown on the radiographs taken in the two planes in cases where only a slight degree of slipping has occurred.

Figs. 500–502 are lateral radiographs showing degrees of spondylolisthesis. It will be noted that the greatest degree occurs in a girl of 13. *Fig.* 500 is a lateral radiograph of Miss G. H., age 25, showing dislocation of the lumbar vertebræ on the sacrum and a bone-graft extending from the 4th lumbar spine

FIG. 500.
Miss G. H., age 25.

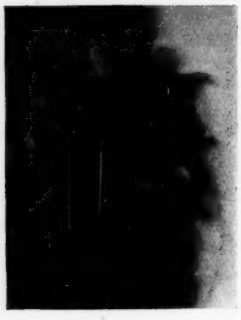


FIG. 501.
Miss P. S., age 15.

FIG. 502.
Miss J. F., age 13.

to the sacrum. *Fig.* 501 is a lateral radiograph of Miss P. S., age 15. It shows a slipping of the 5th lumbar body, the lower border of which forms an angle of 90° with the anterior surface of the 1st sacral body, while its posterior body appears to be lying against the upper part of the anterior border of the sacrum. The laminæ and spinous process appear to be 'drawn out' so that the latter projects beyond the spinous processes of the sacrum and the other lumbar vertebræ. The 4th lumbar laminæ also appear to be a little elongated. The original radiograph shows that the laminæ and spinous process are sclerosed, owing apparently to the pressure to which they are subjected. *Fig.* 502 is a lateral radiograph of Miss J. F., age 13. It shows that the 5th lumbar body has 'slipped' forward to such an extent that its inferior surface is opposed to the anterior surface of the 1st sacral, the superior extremity of which appears to articulate with the inferior surfaces of the laminæ, inferior articular processes, and spinous process, which show the corresponding curvature. The spinous process of the 5th is seen on the original radiograph to project further backward than the spinous processes of the upper lumbar vertebra and the sacrum. These radiographs and the photographs of the specimen in the Royal College of Surgeons Museum (*Figs.* 510, 511) are at variance with the opinion

of Lovett, who states that " the essential point is not so much the subluxation of the body, as the antero-posterior elongation of the body. This always exists and is apparently the pathological condition peculiar to this situation and this condition."

Etiology.—The variety of causes ascribed by different observers for this condition is sufficient evidence in itself to prove that either the cause is unknown or that it is brought about in many different ways. It will be seen from this brief summary that lesions of every structure entering into the formation of the lumbosacral joint have been blamed for the occurrence. Many of the observers believe in the same fundamental cause but attach importance to a particular feature. Neugebauer formulated the theory that it is a static or traumatic deformity of the spine favoured by the imperfect ossification of the laminæ of the 5th lumbar vertebra. He also advanced two other theories: (1) That it is due to arthritis of the lumbosacral joint; and (2) That it is a pressure deformity of the normal vertebra resulting from prolonged physiological strain. Magnuson states that " it is a result of improper bony contact at the articulations and of a loss of bone continuity in the neural arch of the 5th lumbar." Willis and Hey Groves support this. Strasser considers that it is due to a primary arthritis of the lumbosacral articulations. Chian says that abnormal relations of the lumbosacral inter-articular processes due to defective ossification bring it about.

Barnes favours a solution of continuity across the neural arch of the 5th lumbar between its superior and inferior processes on either side. Herrgott thinks it due to inflammatory change following a breach of the vertebral arch by trauma. Braun, Swartz, and Speth all look upon congenital anomalies as the cause. Rokitanski suggests atrophy of the articular cartilage. Lane and Roberts consider it due to excessive weight-bearing which produces thinning and elongation of the neural arch.

Kleinberg and Fitch consider that the condition is due to trauma. Kleinberg is of the opinion that there is an initial developmental defect in the lumbosacral region affecting the body, and more particularly the ligamentous structure, in these cases; also that the position of the lumbar articular processes in the sagittal plane favours a dislocation; but he believes that trauma is the chief factor in the etiology. Darling says it is due to trauma favoured by congenital defect; that it has a gradual onset; and that the symptoms at the time of the injury may be few. Palmer blames the tearing of the ligaments. Lambl says it is probably due to a congenital malformation remotely connected with fœtal hydrorrhachis, traces of which remain in the form of widening of the medullary ring. Albee holds trauma responsible, and states that the body of the vertebra is chiefly affected, whereas the laminæ and spinous processes may remain practically in place. It may be subluxated in part, or its body and anterior half of its arch may be dislocated while the spine and inferior articular surface and the posterior half of the arch may remain in place, in time even be finally ankylosed to the sacrum. Bowman and Goin say it is usually the result of trauma—the injury often being considered of minor importance. They state that "we believe spondylolisthesis is a much more common lesion than it is generally thought to be; that many of them reduce themselves spontaneously, and that many cases of so-called

sacro-iliac slips are in reality cases of unrecognized spondylolisthesis." Most of their patients were men, but the two cases showing the worst deformity were women. The following two cases cited by them are interesting :—

1. A woman, age 65, who awoke one morning with severe pain in her back radiating down the left thigh posteriorly. A herpes developed as the pain continued ; three grains of morphia were required daily to relieve the pain. Neurological diagnosis was " spinal cord tumour at the level of the 4th lumbar ". X-ray examination revealed a spondylolisthesis of the 4th lumbar vertebra. The symptoms were entirely relieved by correcting the spondylolisthesis.

In support of the statement which they make—that in this condition it is quite easy to replace the vertebræ with a moderate amount of manipulation, and that many patients find relief in the hands of chiropractors, osteopaths, and other manipulators—they quote the following case :—

2. A man, age 36, while lifting a section of pipe had a sudden severe pain in the lumbosacral region and was unable to straighten. X-ray examination of the spine revealed a spondylolisthesis of the 5th lumbar. The pain was severe and he was taken to hospital, where it was decided to attempt reduction under anæsthesia. While the surgeons were gently manipulating his legs in an attempt to work out the necessary motions prior to the induction of the anæsthesia, the patient suddenly cried out, and after a few tentative twistings announced that he was cured and the anæsthesia and surgical procedure could therefore be dispensed with —in fact he declined any further attention and went home.

Eden says "the change which occurs is not a dislocation but a displacement due to lengthening and bending of the inter-articular portion of the last lumbar vertebra, as a result of which the vertebral column becomes displaced forwards and downwards. The 1st sacral vertebra becomes gradually torn away by pressure and ankylosis eventually occurs in the morbid position." Nathaniel Mills considers that the asymmetry of the articular processes of the lumbosacral joint renders the joint unstable, so that sudden rotation may cause fracture or dislocation in this area. Hibbs confirms this opinion, and states that a rotation deformity more marked on one side than the other is always found.

Henry, who states that he had had five cases in adult males in a year, believes that it is due to the trauma of modern industry and for that reason is more common in men than women. He is of the opinion that trauma presumably shears off the superior processes of the sacrum. All his cases showed nerve involvement. He says the lesion is a progressive one. First, a slight forward luxation of the 5th lumbar vertebra ; gradually the ligaments stretch and the dislocation progresses, increasing the instability. He says that three of his cases showed congenital anomalies of the articular processes, which face directly upwards. Rose and Carless state that "It arises from fracture of the articular processes of the lumbosacral synchondrosis, or from imperfect development of the laminæ or pedicles of the lowest lumbar vertebra, as a result of which the pressure of loads carried on the shoulders or the weight of a pregnant uterus brings about the displacement."

Wollenberg illustrates a congenital forward dislocation of the vertebræ on the 2nd lumbar, which is smaller than the other bodies. He states that the mother and sister of the patient showed a similar defect. Von Lackum says

that the thinness of the posterior part of the intervertebral disc diminishes its effectiveness as a shock absorber, while the complete absence of spinous processes from the sacrum, with thinner and longer ligaments, increase instability. Ayers considers that spondylolisthesis probably results from the wearing away of the articular facets in a patient suffering from an exaggerated lumbosacral angle.

CASE REPORTS.

The short descriptions of the following five cases and one specimen show that spondylolisthesis is due to several causes.

Case 1.—Miss P. S., age 15.

PHYSICAL SIGNS.—*Figs.* 503–505 show the deformity due to spondylolisthesis. The most obvious feature shown in *Fig.* 503 is the prominence of the sacrum (which appears to be pushed into a more superficial position), and a prominent knuckle at the upper part of this projection. A careful study of the lateral radiograph

FIG. 503.—*Case* 1.

FIG. 504.—*Case* 1.

FIG. 505.—*Case* 1.

(*Fig.* 501) shows that this upper and most prominent spine is the spine of the 5th lumbar vertebra which has been compressed between the superior surface of the sacrum and the 4th lumbar spine. Immediately above this prominent knuckle the spines are not so prominent, but they can be seen and felt. In the dorsilumbar area the spines appear a little more prominent than in the upper part of the column. *Fig.* 504 shows the extent of flexion of the spine permitted by the deformity. The radiograph of the posterior surface (*Fig.* 498) shows a suggestion of a transverse furrow running forward over the iliac crest and an obliteration of the median furrow which normally ends at the 3rd sacral spine and of the surface indications of the posterior superior spines of the ilium.

SYMPTOMS AND HISTORY.—The patient had never experienced any pain or discomfort from the dislocation. No evidence could be obtained from her or her mother that she had ever received injury. Attention was drawn to the deformity by the family doctor during an examination necessitated by an attack of infectious disease six months previously.

RADIOGRAPHS.—The antero-posterior and lateral radiographs (*Figs.* 498 and 501) show the characteristic features of spondylolisthesis. It will be seen that the displacement is symmetrical and that no scoliosis has been produced. The neural arch and spinous processes do not show any evidence of non-fusion with the body. The appearance suggests a similar condition to the specimen illustrated in *Figs.* 510 and 511.

Case 2.—Miss G. H., age 25.

PHYSICAL SIGNS.—*Figs.* 506 and 507 show the deformity present ten years after bone-grafts had been inserted. No photographs are available which would illustrate the condition before operation. The scar of the incision is shown and the prominence of the 'superficial' sacrum. No definite transverse furrows are shown, but there are several 'dimples' in the upper lumbar region.

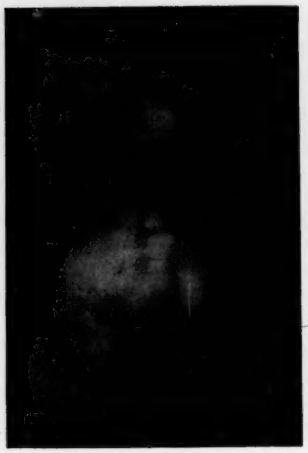


FIG. 506.—*Case* 2.

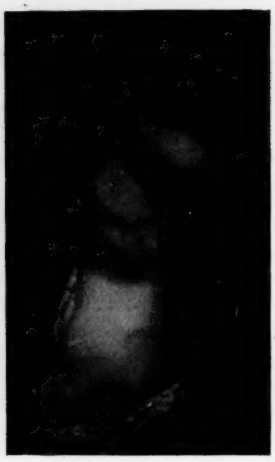


FIG. 507.—*Case* 2.

SYMPTOMS AND HISTORY.—The patient says that she never had any pain, but she 'waddled'. Before the operation she could turn her right leg so far round that the toes faced backwards. She gave a history of a fall on the stairs when she was young.

RADIOGRAPHS.—The antero-posterior and lateral radiographs (*Figs.* 495 and 500) show the characteristic features of spondylolisthesis. The 'slipping' has not been quite symmetrical and there is a slight scoliosis. Two bone-grafts are shown—one from the 3rd lumbar spine to the 3rd sacral spine, and one from the 3rd lumbar spine to the ilium at the level of the sacro-iliac joint. The lower end of the latter graft has expanded but not united with the ilium and has formed a false joint. Radiographs taken before the operation do not suggest any solution of continuity of the neural arch, which appears to be well developed.

Case 3.—Miss J. F., age 13.

PHYSICAL SIGNS.—I have been unable to take photographs illustrating her deformity. She is of stout build, and marked transverse furrows suggest a shortening of the lumbar spine. The back shows a scoliosis with the lumbar curve to the left. The sacrum is prominent; the most prominent spine, as shown in the lateral radiograph (*Fig.* 502), is that of the 5th lumbar vertebra. Immediately above this prominent spine the median furrow begins in a marked depression. On flexion, which is limited, there is a general prominence of the dorsal spine on the right side. The other movements of the spine are normal.

SYMPTOMS AND HISTORY.—No pain or history of any injury. The mother says that the patient did not walk in a normal manner when a child; she always had difficulty in bending forwards with her knees straight.

RADIOGRAPHS.—Antero-posterior and lateral radiographs (*Figs.* 497 and 502) show the characteristic features of spondylolisthesis. The 'slipping' appears from the antero-posterior radiograph to have been symmetrical, but there is a scoliosis of the lumbar spine. They show no evidence of solution of continuity of the neural arch, which appears to be well developed.

Case 4.—Mr. C., age 35.

PHYSICAL SIGNS.—*Figs.* 508 and 509 show that the patient is of short, stout stature. The photograph of his back shows that the median furrow ends at the lower lumbar region, but the sacrum does not appear very prominent. There is no sign of any knuckle kyphos. Transverse furrows above the iliac crests indicate some shortening of the lumbar spine. *Fig.* 509 shows that flexion of the spine is not much impaired; he can touch his toes without bending his knees. It also shows a very slight dip in the bend at the level of the lumbosacral joint.

SYMPTOMS AND HISTORY.—The patient could not give any history of injury

to the spine and had never felt any pain which appeared to be connected with it. At the age of 17 he took up 'physical culture', which he later practised as a professional. Two years ago, when he had symptoms of stone in the kidney for which he was X-rayed, a collection of stones was shown in the right kidney. A pyelograph was made (*Fig.* 496) which demonstrates a hydronephrosis and a collection of stones in the pelvis and calices of the kidney, also an opaque catheter in the ureter which shows the relation of the ureter to the displaced 5th lumbar vertebra.

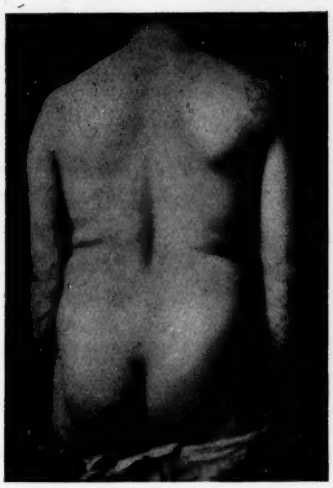


FIG. 508.—*Case* 4.

FIG. 509.—*Case* 4.

RADIOGRAPHS.—The diagnosis of spondylolisthesis was not made until I was recently examining the radiographs, which showed the characteristic shadow of the 5th lumbar vertebra. A lateral radiograph was taken to confirm this diagnosis, and this shows a complete dislocation of the 5th lumbar spine on the sacrum. The radiograph does not indicate any evidence of solution of continuity of the neural arch, which appears to be well developed. It had never been suggested to the patient before—even though he was often seen stripped for his gymnastic performances—that he had any deformity of the spine.

Case 5.—Mr. J. S., age 17.

PHYSICAL SIGNS.—I have been unable to obtain photographs or further radiographs of this patient, as he has left the district. He is of slender build and shows slight transverse furrows with a scoliosis of the lumbar spine to the left and a compensating curve in the dorsal region. He is tender over the lumbar and sacral spine and in the right iliac fossa. He walks with a limp and cannot sit up without external rotation of the right hip. The sacrum is prominent, and the lateral radiograph shows that the upper extremity of the prominence is due to a projection of the sacrum and that there is no spinous process of the 5th lumbar.

HISTORY AND SYMPTOMS.—He complains of pain in his right hip-joint. Two years ago he says he fell off his cycle and injured the right hip, which caused him to remain in hospital for ten months.

RADIOGRAPHS.—The antero-posterior radiograph is not very good, but it shows a faint outline of the characteristic border of the 5th lumbar body with poor development of the neural arch and failure of fusion of the laminæ. The lateral radiograph shows a complete dislocation of the 5th lumbar on the sacrum.

Case 6.—Specimen of the lumbosacral region of a spine in the Museum of the Royal College of Surgeons.

Figs. 510 and 511 illustrate the two sides of the specimen. The cut surface shows a forward dislocation of the lumbar spine on the sacrum and a heaping up of the lumbosacral intervertebral disc behind the body of the 5th lumbar. The neural canal widens gradually from the level of the 2nd lumbar vertebra

to the lumbosacral joint, and with this widening the laminæ are drawn out into long processes which in the photograph appear darker than the other bone, owing to an artificial red staining of the processes for museum purposes. The spine of the 5th lumbar is shown to project posteriorly further than the spinous processes of the vertebræ above or below, and there is no suggestion of poor development of the neural arch.

FIG. 510.—*Case* 6.

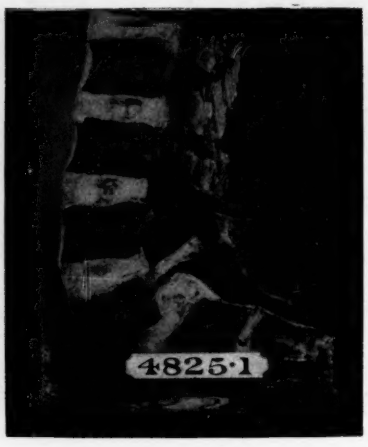


FIG. 511.—*Case* 6.

HISTORY.—The history states that there was no evidence of any injury. This widening of the neural canal and the 'drawing out' of the laminæ suggest that if the condition is due to trauma, the injury must have taken place in early life.

A review of the features of these cases shows that the lesion occurs early in life, apparently without any symptoms, and may never be diagnosed unless for some reason it is suspected. To the obstetrician this is of great importance, for the deformity will prevent normal delivery. Its presence will be suggested to him by an examination of the 'rhomboid or lozenge of Michaelis'. This is indicated on the surface by the oblique furrows formed by the medial borders of the glutei maximi, which come together in the mid-line distally and appear to end in the shallow depressions over the posterior superior spines of the ilium on either side. The upper borders of the rhomboid are formed by lines joining the latter depressions to the depression usually present over the 5th lumbar spine. The essential measurements of the rhomboid are the distances between the posterior superior spines of the ilia and the vertical distance from the mid-point of the line joining these two points to the 5th lumbar spine. The average of the former in the normal is 4 in., of the latter $1\frac{1}{2}$ to $1\frac{3}{4}$ in. It will be seen from the photographs that the median depression which marks the 5th lumbar in the normal is not present in those patients having the deformity.

In only one case is there a definite faulty development of the neural arch, and in this there is a history of a severe injury. This and the other features described suggest that trauma is the probable cause and that the injury is often sustained in early life—even at birth.

Spondylolisthesis and other conditions which narrow the pelvis lead to great difficulty in obstetrics, and the child is sometimes so forcibly pulled, crushed, twisted, or turned that the skull, ribs, or limbs are broken or birth palsies are produced. Therefore, while spondylolisthesis in the mother leads to difficulty in childbirth, difficulty in childbirth may lead to spondylolisthesis in the child.

Physical Signs and Symptoms.—Two types of spondylolisthesis have been

described: (1) Unilateral, which is said to be accompanied by pronounced early paralysis due to compression and displacement of the corda equina. (2) Bilateral, which is a gradual process only accompanied by mild symptoms —the common type.

Pain.—Pain may be absent altogether. This was so in four of the cases I have reported. Nerve disturbances, which may be temporary, permanent, or recurrent, have been described by Ryerson and others. One of the patients mentioned above had a hydronephrosis with stones, but it was impossible to say what relation this bore to the dislocation, as the latter was not suspected at the time of the operation. Creyssel describes a case of spondylolisthesis in which adhesions around the dislocation involved the ureter and produced a hydronephrosis.

Limitation of Movement.—Flexion of the spine is usually restricted; this was so in four of my cases, but in one there appeared to be no restriction.

Gait.—Two of the five patients showed no abnormality, two had a slight waddle, and one a marked limp. Lovett describes the gait as resembling that of a quadruped.

Posture.—Trunk shortened. This may be shown by transverse furrows which encircle the body between the ribs and the iliac crests, diminution of the space between the ribs and the iliac crests, and between the ensiform cartilage and the pubis.

The sacrum is prominent, and, as shown in four of my cases, there is a still greater prominence of the 5th lumbar spine, with a depression above. In the female a vaginal examination will show a diminution of the true conjugate or antero-posterior diameter of the pelvic inlet. Only one patient had any difficulty in extending the legs—this is suggested as one of the signs of the displacement. Some authorities state that the abdomen is pendulous and the buttocks are prominent; this was not seen in any of my cases.

Differential Diagnosis.—Two of the five patients were diagnosed as tuberculous caries of the spine owing to the localized kyphos deformity. Radiographs and photographs of patients showing the deformity produced by tuberculous caries of the 5th lumbar and 1st sacral vertebræ are shown in *Figs.* 542–544 and 548. As a rule, with tubercle, pain is a prominent early symptom, often before any sign of a deformity, whereas in these cases of spondylolisthesis four had no pain. The prominence of the sacrum is not observed in tubercle. Radiographs will give conclusive evidence of spondylolisthesis or tubercle in the cases with deformity. Congenital deformities of the lumbosacral spine may also produce kyphosis; the nature of these will be shown by the radiograph.

Treatment.—Ryerson first reported a case of spondylolisthesis treated with a bone-graft. Albee immobilized the spine by bone-graft in eight cases. He says "the 4th and 5th lumbar vertebræ tend to pull themselves away from the graft and in an antero-posterior direction: the graft being inserted into their spinous processes is firmly pressed against the posterior surface of the sacrum." Cases have also been treated by Hibbs's method of lumbosacral fusion. Bowman and Goin consider that many cases of spondylolisthesis are reduced spontaneously. The authorities who either do not favour the open operation or who cannot obtain permission to operate, treat the patient by

spinal supports, exercises, and massage. Turner and Tchirkin state that "It is doubtful whether operative measures can aid conservative treatment in alleviating the symptoms and arresting the progress of the ailment." A study of the specimens and radiographs in my cases negatives the suggested possibility of manipulative reduction of the displacement.

V. DEFORMITIES DUE TO INJURY.

Deformities of the lumbosacral region of the spine due to fracture are not very common. When such a fracture does occur it is owing to very severe trauma. In the previous pages of this paper it has been indicated that trauma may produce a narrowing of the lumbosacral angle and spondylolisthesis, but the commonest fracture of the spine is the compression fracture of the vertebral body. This type is chiefly seen in the 5th and 6th cervical and the 12th dorsal and 1st lumbar. The fracture is usually due to forced hyperflexion, but the force necessary to produce it appears to vary greatly in different individuals. It is seldom that this type of fracture is seen in the lower lumbar region. The clinical and radiographic evidence will vary with the degree of trauma and the condition of the bone. As a general rule it may be said that the more obvious the clinical deformity, the greater the bone or joint abnormality shown on the radiograph.

In some cases if the patient is examined in the first few days, little sign of the deformity may be seen. The patient will usually complain of pain and tenderness in the region of the fracture and there may be obliteration or departure from the normal antero-posterior curvature. Antero-posterior and lateral radiographs may not show any definite bone deformity. Gradually with the absorption, organization, and compression of the damaged tissues, the deformity begins to show. Several patients were radiographed within a few hours of their injuries and the pictures show little sign of compression of the vertebræ, but a week or so later a definite wedge-shaped compression of the vertebral body could be detected on the lateral radiograph (*Fig.* 512); no attempt had been made in the interval to prevent movement. This rather suggests that a greater degree of deformity will result if the injured vertebral body is not relieved of all compression during the process of repair. Such fractures may be produced in old people with relatively trifling injury, and therefore may be quite unsuspected until perhaps a definite kyphosis is seen. If this has taken several weeks to develop, its appearance may not be related to the injury and may give rise to a suspicion of pathological destruction of the bone—tubercle or neoplasm, for example. It is probably owing to this delay in the production of the deformity that this appearance of the vertebral body has been described as Kümmel's disease, which is defined as a non-tuberculous rarefying osteitis of the vertebral bodies accompanied by softening and collapse of the bodies.

FIG. 512.—Lateral radiograph showing wedge-shaped compression fracture of the body of the 12th dorsal vertebra due to sudden hyperflexion of the trunk.

In some patients who have had injuries to the back, the bone damage is not so extensive and deformity may not be seen for several months. This is due to the fact that the injury has chiefly involved the ligaments and the intervertebral discs ; and the bones preserve their normal positions. Gradually the damaged intervertebral discs contract, sometimes more on one side than the other, the vertebral bodies are brought into closer contact with one another, and as they are not so well protected by the buffer action of the disc, they are subjected to more strain. This causes a sclerosis and 'lipping' of the margins of the vertebral bodies and often a calcification of the connecting ligaments, which can be shown on radiographs of such injuries. If the damage has been greater on one side, a curvature will develop, which often gives rise to a compensatory curvature in the vertebræ above. The opposing borders of the vertebral bodies on the concave side of these curves will undergo a similar process. *Fig.* 513 shows the bone and joint changes five years after an accident which damaged the lumbosacral joint. It shows a sclerosis of the bone in the neighbourhood of the left side of the lumbosacral joint and ossification of the connecting ligaments. There is also sclerosis and lipping of the bodies of the 2nd and 3rd lumbar vertebræ on the right side—the concave side of the curvature. *Fig.* 514 is a radiograph of a man, age 71, who gave a history of an injury to the lower part of his back thirty years before. He is now complaining of 'lumbago' and 'sciatica'. This radiograph shows similar features to *Fig.* 513, but the 'lipping' is more marked. Jones and Lovett have pointed out that "in all cases of spinal fracture, however slight, there is a history of trauma, whether direct or indirect ; but it must be remembered that the effects are not necessarily immediate and may reach their maximum a good while after the injury."

FIG. 513.

FIG. 514.

The laminæ and spinous processes of the lumbar vertebræ are stronger and better protected against injury than the cervical and dorsal vertebræ, consequently fractures of these processes are rare unless they are part of a more extensive injury. They have been reported in cases of traumatic spondylolisthesis and as a result of direct blows over these processes. Such fractures in some cases cause compression and damage to the corda equina and paralysis may follow. *Fig.* 516 shows a fracture of the laminæ of the 5th lumbar vertebra in a man, age 36, who fell 16 feet from a tree and landed on his buttocks. Radiographs showing non-fusion of the laminæ might be interpreted as fracture of the laminæ (*see Figs.* 457 and 458).

Balensweig cites two cases :—

1. A labourer, age 45, slipped down some steps whilst he was carrying a load of wood. Subsequent radiographs showed a forward dislocation of the 4th lumbar on the 5th.

2. A carpenter, age 54, fell 14 feet and landed on his buttocks. Twelve months after he complained of pain in the lower lumbar region which radiated down the left leg. The movements of his spine were restricted, especially extension ; and there was a loss of the normal lumbar curvature. No angulation or depression could be seen above the sacrum. He was tender in the gluteal region and along the course of the sciatic nerve. A lateral radiograph showed a displacement of the lumbar spine on the sacrum of about $\frac{3}{16}$ in. A bone-graft was inserted : the patient has since developed a radiculitis probably due to osteo-arthritis, and is now incapacitated.

Figs. 515 and 516 are antero-posterior and lateral radiographs showing 'pre-spondylolisthesis'. *Fig.* 515 shows sclerosis of the pedicles and the right superior and inferior articular processes of the 5th lumbar vertebra with little upward displacement of the latter and approximation of the spinous processes. *Fig.* 516 shows a sharp lumbosacral angle and gives the suggestion of a slight dislocation of the lumbar vertebræ on the sacrum. The laminæ show an irregular fracture line which indicates a separation of the superior from the inferior articular processes, all of which exhibit some irregularity. The spinous process of the 5th lumbar vertebra is on a higher plane relative to the vertebral body than is the case in the normal. This appearance is quite different from the abnormality demonstrated in *Fig.* 443. This patient, a man, age 35, fell 16 feet from a tree and landed on his buttocks ten years ago. He now presents a slight lumbar curvature and complains of pain in the lumbosacral region.

FIG. 515.

FIG. 516.

Fracture of the transverse processes occurs from direct and indirect injury ; they are frequently fractured by hyperflexion of the trunk. Sudden unopposed contraction of the quadratus lumborum is said to produce a fracture of these processes—certainly fractures become more obvious radiographically by the pulling apart of the broken extremities with contraction of the quadratus lumborum. The 3rd lumbar transverse processes are most frequently fractured ; this may be due to their greater length. The costal element of the transverse processes of the 1st lumbar vertebra is sometimes formed from a separate epiphysis which fails to fuse with the body of the vertebra and forms a lumbar rib. This has been interpreted from the radiograph as a fracture of the transverse process. I have pointed out that the costal element

of the 5th lumbar vertebra which is developing sacral characters has also a separate centre of ossification, and a line indicating that this has no bone union with the vertebral body may be shown on the radiograph and lead to an erroneous interpretation of fracture. The shadow of the lateral border of the psoas as it passes over the transverse processes, and the difference in density of the main mass of the process and its thickened lateral extremity, may also give a false impression of fracture. *Fig.* 517 illustrates a fracture of the iliac crest and the transverse process of the 4th lumbar vertebra with an irregular process of new bone attached to the 4th transverse process and articulating with the iliac crest. This new bone formation followed a septic infection of the wound which occurred seven years before this radiograph was taken.

FIG. 517.

With a complete fracture-dislocation of the spine, the upper part of the vertebral column is usually displaced forwards on the lower, and the spinal cord or corda equina is stretched over the top of the body of the vertebra heading the lower column, and between it and the arch of the vertebra which was above. *Figs.* 518–520 are examples of the serious types of fracture which are met with in this area. *Fig.* 518 shows a fracture-dislocation through the 1st lumbar vertebra with a lateral displacement of the fragments. This patient was thrown out of the side-car of a motor cycle by a collision with a car. She sustained in addition a fracture of one femur and of the base of the skull. The spinal deformity was not well marked, and owing to this and her other injuries it was not discovered for over a week. She had some paresis of the lower extremities and incontinence, but the condition has improved and she is still alive and well enough to be wheeled about after two years.

FIG. 518.

Figs. 519–521 are pictures of a miner, age 40, who was crushed by a heavy mass of coal which fell

FIG. 519.

FIG. 520.

on his shoulders as he was working in the mine. The radiographs show that there was a complete separation of the innominate bones from one another and a vertical fracture of the right side of the sacrum, with an upward displacement of the right side; also fractures of the left transverse processes of the 2nd, 3rd, and 4th lumbar vertebræ. *Fig.* 521 shows his present condition and deformity; the buttock is seen to be much higher on the right side than the left. He had no bladder symptoms and is able to do regular light work.

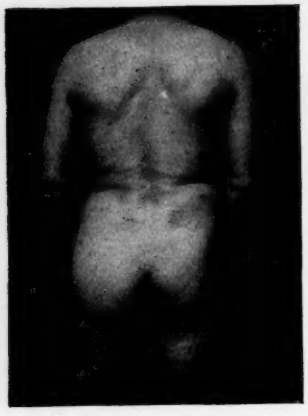


Fig. 521.

Bowman reports that in his experience compression fractures of the vertebral bodies occur in the following order: 1L, 12D, 2L, 11D, 5L, 5 and 6C. Herndon found fractures of the vertebræ in 71 out of 941 cases of injuries to the back; 41 involved the vertebral processes; 30 involved the vertebral body, and 12 of these were 1st lumbar vertebræ. Von Lackum states that in a review of the fracture-dislocations of the spine at the New York Orthopedic Dispensary and Hospital during the last twelve years it was found that the majority of those lesions took place in the lumbosacral region.

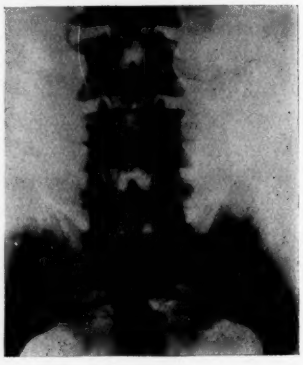


Fig. 522.

Fig. 522 is a radiograph showing 'lipping' of the left borders of the 2nd and 3rd lumbar vertebræ. The patient gave a history of an injury to this part of the back two years before.

VI. DEFORMITIES DUE TO PATHOLOGICAL CHANGES IN THE BONES AND JOINTS.

The pathological changes which produce deformity are caused by: (1) Organisms of acute infections such as staphylococci, streptococci, pneumococci, gonococci, and typhoid bacilli. (2) Organisms of chronic infections—tubercle, syphilis, actinomycosis. (3) Neoplasms—simple and malignant. (4) Deficiency diseases and other bone diseases such as rickets, Paget's disease, and osteomalacia.

ACUTE INFECTIONS.

Osteomyelitis.—Acute osteomyelitis of the spine is fatal in the majority of cases; in the survivors the degree of deformity will depend on the amount of bone and ligament destruction. As a rule there is no great loss of tissue bulk, and as the condition enforces almost absolute rest of the spine, deformities due to the weight of the trunk on the damaged bone do not arise. The chief deformity seen on a clinical examination is rigidity of the part of the spine involved, owing to bone ankylosis of the intervertebral joints, and ossification of the ligaments. Greater deformity results if any

strain is placed upon the parts before healing is complete. Radiographs will not show any evidence of acute osteomyelitis in the early days; later, rarefaction of the bones may be seen; later still, erosion of the bone. Those cases in which a chronic inflammatory process persists will show a varying amount of bone destruction and, if healing is taking place, sclerosis of the surrounding bone. Sequestra may be shown and can be recognized because the dead bone retains its calcium and therefore its opacity to X rays, whereas the living bone is partly decalcified owing to the presence of toxins and the disuse necessitated by the lesion. Further, if the condition has originated in a fracture and some of the detached fragments of bone have died, they will retain their sharp fracture contour; the borders of the living bone will be round.

Fig. 523 represents the lumbosacral area of a patient, age 45, who had a gunshot wound of the right side of the lumbosacral joint ten years ago. A sinus persisted which healed over from time to time. One year ago an abscess was opened in this area. The picture shows some irregularity of the right side of the lumbosacral joint and sclerosis of the surrounding bone. An irregular, curved, slender sequestrum can also be seen which appears to lie parallel to the crest of the ilium. The anterior common ligament is ossified and the left transverse processes are irregular and pointed owing to ossification of the iliolumbar ligament and fascia attachment.

FIG. 523.

Whitman gives the following tables showing the situation of the lesion in acute osteomyelitis of the spine in 61 collected cases :—

Cervical region	12
Thoracic „	15
Lumbar „	24
Sacral „	10

He states that in 30 of 56 cases reported by Grisel the patient died of general infection, pleuropneumonia, or meningitis before the diagnosis had been made and before an abscess developed.

	Recovered	Died
Suboccipital	1	4
Cervical	2	2
Dorsal	7	3
Lumbar	13	15
Sacral	0	6
	23	30

Arthritis.—As a complication of several of the infectious diseases—small-pox, typhoid, yaws, dysentery, pneumonia, scarlet fever—arthritic conditions may arise. Most of these completely resolve, but when associated with pyogenic infection of the joint, necrosis of bone is liable to occur, or

destruction of the articular cartilage with resulting bone ankylosis and spinal curvature.

Occasionally, as a complication of gonorrhœa, practically all the articular surfaces of the spine fuse together to form a fixed rigid column, as if some osteoplastic substances had been secreted into the joint which had welded the surfaces together without any evidence of bone destruction or over-production from the external surfaces. Such patients present a general rigid kyphosis. *Fig.* 524 shows fusion of all the articulations of the lumbar and sacral joints. The original radiograph shows a general uniform rarefaction of all the bone, which appears to have lost its normal striæ. There is no evidence of ossification of the anterior common ligament. The patient gave a history of acute rheumatism following an attack of gonorrhœa two years previously. Verrall says that gonorrhœa is responsible for 65 per cent of all cases of severe arthritis with rigid spine, and that about 30 per cent are due to absorption of toxic products from the alimentary tract.

FIG. 524.

Typhoid spine is rare. The complication is most common in young adult males in an estimated proportion of 1 to 1800 cases of typhoid fever. In 36 per cent of 53 cases of typhoid spine investigated by Silver, local deformity indicated a destructive process (Whitman).

With complete bone ankylosis of the spine, the lumbar spine is flat, the dorsal spine forms a marked regular kyphosis, the curve of which is continued into the cervical area. Such a patient has no rotation of the spine and consequently has to turn his whole body if he wishes to look behind him, as in the type described by Bechterew. In those cases in which in addition ankylosis of the hips and shoulder-joints occurs the patient will have difficulty in retaining his balance when standing without supports. This type is described as the Marie-Strümpell variety.

A similar appearance to that seen in *Fig.* 524 is often shown on the radiographs of patients who have suffered from a non-specific arthritis. The cause of this type of arthritis is generally thought to be an absorption of toxic products from some septic focus—sinuses, teeth, alimentary tract, gall-bladder, for example. Other authorities suggest that it might be a deficiency disease. *Figs.* 525 and 526 are antero-posterior and lateral radiographs of the lumbosacral area of a man, age 49, nine years after an acute arthritis. They show ossification of the anterior ligament, interspinous

FIG. 525.

FIG. 526.

ligaments, and right iliolumbar ligament; the latter shows an irregularity near the crest of the ilium suggesting incomplete fusion. *Figs.* 527 and 528 are antero-posterior and lateral radiographs of the lumbosacral region of a man, age 54, fourteen years after an acute attack of rheumatism which compelled him 'to keep to his bed' for eight months. They show ossification of the anterior common ligament and fusion of the articular surfaces of the lumbar and sacral vertebræ, with 'lipping' of the articular margins.

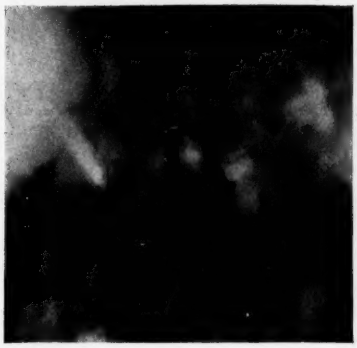


FIG. 527.

FIG. 528.

Figs. 529 and 530 exhibit a complete bone ankylosis of the lumbosacral spine, the result of an acute non-specific arthritis contracted eleven years previously.

In the collection of arthritic spines shown to me by Mr. Lawford Knaggs are specimens which show ossification of the anterior common and other spinal ligaments. They present the appearance which one might expect to be produced if the ligaments had undergone ossification after a preliminary swelling of the fibres by a sort of mucinous degeneration: they look as if some stringy, viscid substance had run down over the surfaces of the vertebræ, adhered more to one place than another, and had then been petrified. The bones of ancient Egyptians in the Royal College of Surgeons Museum have a similar appearance.

FIG. 529.

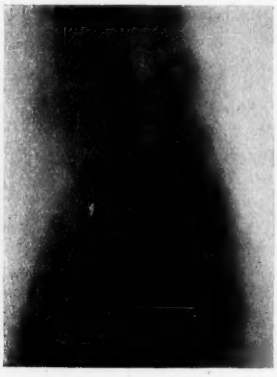


FIG. 530.

The radiographs taken of the post-mortem specimens in which ossification of the ligaments and 'lipping' of the articular margins had occurred show that the new bone is denser and therefore more opaque to the X rays than the normal bone.

Osteo-arthritis.—Deformities of the lumbosacral region of the spine due to osteo-arthritis depend on: (1) The nature and duration of the causes; (2) The localization and extent of the pathological changes; (3) The character and distribution of the pain associated with the lesion. The condition appears to be often associated with trauma—particularly with a repetition of slight degrees of trauma—in the presence of absorption of toxic products from some septic focus. It is therefore frequently seen in patients whose occupations

necessitate the lifting or carrying of heavy weights or the regular assumption of any position in which the ligaments controlling the extent of articular movement are strained. Sir Arbuthnot Lane has shown that this localized increase of articular stress from an occupational origin produces deformity which is characteristic of certain occupations. Any condition which alters the balance of the trunk—such as congenital mal-development, disease, or fracture involving the lower extremities, pelvis, or spine—will throw abnormal strain on the ligaments and bony processes of the spine—particularly in the lumbosacral area—which have to assume the new position in an attempt to correct the deformity produced by the lesion.

Large joints like the hip- and knee-joints affected with osteo-arthritis show destruction of the central part of the articular cartilage with irregular erosion and eburnation of the denuded bone and proliferation of the cartilage and the formation of villous processes near the edges of the joint. An irregularity of the articular surface is therefore produced. The articulations of the spine seldom show such marked changes. The specimens which I have examined showed the articular surfaces to be hard and smooth and their margins sharp, but around the margins irregular bosses of new bone had been laid down. These features are shown in *Figs.* **531** and **532**. On the radiographs therefore, even with marked osteo-arthritis of these articulations, no irregularity may be seen of the articular surfaces (*see Figs.* **533, 535**). Putti says that "the articular surfaces instead of appearing smooth and parallel appear jagged and rough." 'Lipping' of the borders of the vertebral bodies occurs, and may be so extensive that the processes of new bone meet and fuse with similar processes on opposing borders of other vertebral bodies. This dense new bone formation on the front of the lumbosacral joint may be so massive as to suggest an ivory exostosis. Usually it appears on the antero-posterior radiograph as a dense crescentic line which may be misinterpreted as spondylolisthesis, particularly as it often occurs in association with a reduced lumbosacral angle. The osteo-arthritic changes

FIG. 531.—Superior surface of the sacrum showing ' lipping ' of the margins of the veterbral body, the flat surfaces of the articular facets with their sharp articular margins, and bosses of new bone on the posterior surface of the body and the anterior surfaces of the articular processes which narrow the nerve canal.

FIG. 532.—Anterior surface of sacrum showing ' lipping ' of the superior border of the body. The object above is a separate neural arch of the 5th lumbar which belongs to the same specimen. It shows that the articular surfaces are smooth and flat, but, above these, irregular masses of new bone have been laid down.

may be localized to the lumbosacral elements and the radiographs may show that the new bone formation is chiefly on the bodies, the non-articular surfaces of the articular processes, or even the spinous processes. Descriptive radiographs illustrating these features are well shown in *Figs.* 533–540. Timbrell Fisher reports that in 95 per cent of the cases of osteo-arthritis which he investigated, he found a definite focus or foci of septic absorption, and in every case amelioration or cure was produced by removing the focus.

FIG. 533. — Early osteo-arthritis of the lumbosacral articulations. In contrast with the upper articulations the 'sub-articular' bone is sclerosed and the superior margins of the superior facets of the sacrum are pointed. This appearance is in agreement with the description of the specimen shown in *Figs.* 531 and 532. It also shows the crescentic line due to 'lipping' of the anterior surface of the lumbosacral joint.

FIG. 534. — Radiograph showing dark crescentic line due to ossification of the anterior common ligament over the lumbosacral joint.

Figs. 535 and 536 are antero-posterior radiographs of a patient, age 65, who complains of 'sciatica' and 'lumbago'. *Fig.* 535 is taken with the X-ray tube vertically over the patient, *Fig.* 536 with the tube tilted so that the central ray is approximately parallel with the inferior surface of the body of the 5th lumbar vertebra. They show marked 'lipping' of the margins of the vertebral bodies. The articular surfaces of the lumbosacral articulations cannot be seen as they are facing forwards, but the joint spaces of the vertebræ above are shown in the sagittal plane, and

FIG. 535.

FIG. 536.

FIG. 537. — Radiograph showing osteo-arthritic changes chiefly affecting the 5th lumbar vertebra and the lumbosacral articulations.

FIG.. 538—Illustrating a similar condition to *Fig.* 537, but the changes are much more marked.

these seem quite regular and suggest no irregularity of the articular surfaces.

FIG. 539.—Osteo-arthritic changes in the false joints between the spinous processes.

FIG. 540.—Osteo-arthritic changes in the false joint between the laminæ of the 5th lumbar vertebra which have not fused.

Fig. 541 is a series of radiographs of teeth showing apical abscesses in different patients suffering from arthritis.

The pain associated with osteo-arthritis of the lumbosacral region of the spine may vary in its character and distribution. In some cases it consists of a dull ache which may be intensified when the patient lies in bed and may be accompanied by occasional sharp stabbing pains. In other cases the

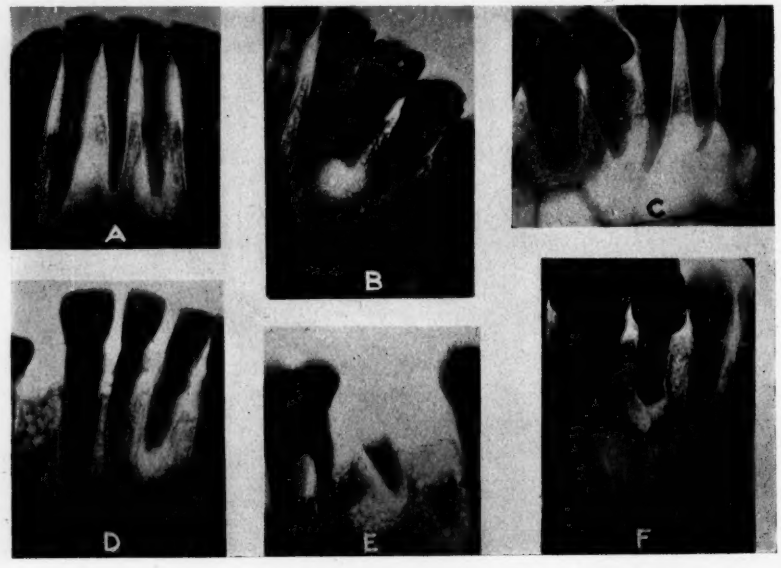


FIG. 541.

patient has acute attacks of sharp pain which may be localized to the trunk or radiate along the course and distribution of the sciatic nerve, with intervals of comparative freedom. Such attacks may be brought on by some sudden movement or strain and give the suggestion that they may be due to 'nipping' of villous overgrowths which develop around the margins of the osteo-arthritic joints—between the articular surfaces. For some days or even weeks after the initial sharp pains similar pains may be brought on with much less trauma

to the injured tissue, which, together with the fact that the pain may be suddenly relieved by a particular movement, suggests that the damaged process is still between the articular surfaces. In some cases the pain causes a protective contraction of the muscles, which may imprison the sensitive tissues, and the pain persists until, perhaps, the contraction is overcome by manipulation. There is no doubt that something of this nature does occur, and the manipulator, whoever he may be, gets much credit from the patient for his 'lightning' cure.

Three types of scoliosis have been described as occurring in sciatica: (1) Contralateral scoliosis (Brissaud)—the spine curves laterally, displacing the trunk to the side away from the pain; this results in the separation of the intervertebral joints on the painful side and widens the nerve canal. (2) Homolateral scoliosis, in which the trunk is displaced towards the painful side; this is said to relax the inflamed joints and nerve cords. (3) Alternating scoliosis, due to bilateral lesions (Remak). The following signs have also been described: (1) Rigidity of the lumbar spine; (2) Lasègue's sign—pain caused by extension of the knee with simultaneous flexion of the hip; (3) Absence of knee- and ankle-jerks; (4) Muscle atrophy; (5) Sensory changes. When the pathological changes are confined to the lumbosacral joints, the part is kept rigid, and as forward movements take place from the hip-joint they are limited when the patient is sitting.

Professor Osgood and Dr. Morrison, of Boston, have compiled a list of causes of low back pain.

Sicard is of the opinion that many 'neuralgias' of the trunk take origin from some skeletal peculiarity—in fact, are the result of compression or strain on nerves or nerve-roots where they traverse bony canals: he calls the condition a 'nevrodocitis'. He says that laminectomy in such cases has brought relief. He considers that a primary articular arthritis induces a secondary reaction in the nerve-roots.

TREATMENT.—Putti recommends hyperæmia and immobilization for the treatment of sciatica due to arthritis of the vertebral articulations, and describes a case of thirty years' duration which was completely relieved by removal of the laminæ of the 3rd, 4th, and 5th lumbar vertebræ and also the articular processes of the 4th and 5th lumbar and the superior articular processes of the 1st sacral. Sicard has also advised laminectomy of the 3rd, 4th, and 5th lumbar vertebræ. Arthrodesis of the affected vertebræ by the method of Hibbs or Albee has been performed by other surgeons, as in some cases it is found that the pain becomes less as ankylosis takes place. Barse and Gunsett treated 20 cases of vertebral arthritis by X rays and claim that 12 were cured, 5 had much less pain, but in 3 cases there was no change. Those cases with pain as the dominant symptom responded best. Pfender also advises X-ray treatment, which he says acts on the connective tissue surrounding the nerve in the intervertebral foramen and reduces the inflammation and swelling. Septic foci should be searched for and eradicated if possible.

CHRONIC INFECTIONS.

Tuberculosis.—

FREQUENCY.—Tuberculous caries of the spine occurs most frequently

between the ages of 3 and 5. In a series of 1259 cases recorded by Whitman, 50·2 per cent occurred between 3 and 5 years of age and 82·7 per cent between 2 and 10. The commonest site of the lesion is the dorsilumbar area as in compression fractures, which suggests that trauma may have some influence. It does not, however, show the same relative incidence as fracture of the lower cervical vertebræ. In a series of 1284 cases reported by Whitman, the distribution of the disease was: Cervical 100, dorsal 854, lumbar 317, lumbosacral 13. In a series of 178 cases of spinal caries treated at The Royal Cripples Hospitals, Birmingham, I found that the disease involved the lumbosacral vertebræ in 8 cases.

Physical Signs and Symptoms.—The early symptoms noted are pain and muscular rigidity. The pain may be located in the lower part of the back, or it may radiate along the course of the sciatic nerve into the thigh. The degree of pain varies from slight to very severe. Frequently the earliest sign in upper lumbar caries is an increase in the lumbar lordosis, but in the lumbosacral area this sign is not often detected. The earliest sign in this region is usually rigidity of the part, as a result of which hyperextension, lateral movement, and forward flexion when the patient is sitting are restricted. As the condition progresses, the median furrow of the back, which normally ends at the level of the 3rd sacral spine, is gradually obliterated in the region of the 5th lumbar vertebra; the lumbar curve flattens, and eventually a definite kyphos may be produced as shown in *Figs.* 542, 543, and 548. The lesion if untreated may result in complete destruction of the vertebral body of the 5th lumbar or 1st sacral or both, and as a result of the superincumbent weight the upper lumbar vertebræ will be dislocated on the sacrum.

Complications.—

Abscess Formation may occur as a complication, and the fluid contents may track in various directions and appear as tumours. As a result of the destructive processes, tuberculous material will generally begin to accumulate under the anterior common ligament, and this may: (1) Form a large pelvic abscess on the front of the sacrum which may remain undetected until accumulation of carious bone and other calcareous deposits occur which cast a shadow on the radiograph, as in *Fig.* 549. (2) The fluid contents of such an abscess may track along the iliac fascia and appear at the outer extremity of Poupart's ligament as an iliac abscess. (3) Perforate the sheath of the quadratus lumborum and appear in Petit's triangle as a rounded swelling—a lumbar abscess. (4) Pass along the iliac artery and appear in the thigh. (5) Track through the great sacrosciatic foramen and form a swelling in the gluteal region—a gluteal abscess. (6) Perforate the rectum, intestine, or bladder. These abscesses may occur singly or they may be bilateral. Whitman says that they are to be expected as a complication of lumbar caries in 50 per cent of cases. When the psoas is involved by the abscess formation the muscle contracts and produces flexion of the thigh and flattening of the lumbar curvature.

Paralysis as a complication in lumbosacral tubercle appears to be rare. *Fig.* 546 shows marked destruction and crushing of the lower lumbar bodies which one might have expected to lead to crushing of the nerves in the intervertebral foramina; but *Fig.* 547 shows well-defined nerve foramina, and suggests that the nerve has some control over the new bone formation in its

immediate neighbourhood, and so determines the size of the foramen through which it must pass.

X-RAY APPEARANCES.—In the early stages of the disease even though definite clinical signs may be present, radiographs may show no change in the bone; yet other cases occur in which the clinical signs are indefinite, but lateral radiographs show areas of bone rarefaction and absorption indicating definite bone destruction. It is probable that such anomalies are due to a different location of the tuberculous focus and the line of progression which it takes. Commonly the pathological changes are first seen in the juxta-epiphysial areas near the superior and inferior surfaces of the vertebral bodies. When the process extends into the bone, destructive changes occur which can be shown on the radiograph, but the ligaments and external surfaces of the bones are not involved; therefore the clinical features may be few, unless, as sometimes happens, the diseased bone is injured. In the latter case the typical clinical features may develop after a few days, as in those cases where the lesion has previously been near the surface of the bone and involved the ligaments early.

Radiographs may show around the diseased rarefied area some sclerosis of the bone, but in those patients in whom the resistance to the infection is poor, the rarefaction is more extensive and there is little evidence of sclerosis. When the lesion has involved a large proportion of the vertebral body the radiograph will show a 'stippled' appearance of the bone, probably caused by small necrotic bone fragments and irregularity due to erosion of the outline of the body, which is gradually crushed between the upper and lower vertebral bodies. There is usually little or no evidence of new bone formation at this stage, unless there has been a secondary septic infection of the part. When several vertebral bodies are involved the intervertebral discs are destroyed, and the bodies are crushed into what appears on the radiograph as a structure-less irregular wedge-shaped mass. In the dorsal and upper lumbar area, but seldom in the lumbosacral area, a dense spindle-shaped shadow will be seen to involve the shadows of the diseased vertebræ, giving the appearance of a plumber's 'wiped' joint. This is due to thickening of the surrounding tissues and abscess formation. This shadow becomes denser as calcification of the abscess occurs, and it can then be seen in any part of the spine (*see Figs.* 549 and 550).

A series of radiographs of the healing lesion will show an increase in the density of the bones and a 'rounding off' of the margins of the bones involved. The bone shadows will lose the 'stippled' appearance and become uniform in density. As a general rule the radiographs show little 'excessive' new bone formation.

DIFFERENTIAL DIAGNOSIS.—The appearance of a knuckle kyphos may be due to: (1) Congenital abnormalities of the neural arch; (2) Spondylolisthesis; (3) Inflammatory lesions other than tubercle; (4) Neoplasms; (5) Aneurysm.

1. *Congenital Abnormalities* are often unaccompanied by pain, and antero-posterior and lateral radiographs will show the nature of the abnormality.

2. *Spondylolisthesis* generally shows a characteristic deformity of the lumbosacral area, often unaccompanied by pain. Tuberculous destruction

sufficient to produce this deformity would be accompanied by pain, muscle rigidity of the part, and probably abscess formation. The radiographs will show the dislocation of the vertebral bodies, which are regular in outline and density.

3. *Inflammatory Lesions other than Tubercle* are usually accompanied by more new bone formation, and radiographs will show this and often 'lipping' of the vertebral bodies adjoining.

4. *Neoplasms.*—

a. Sarcoma usually shows a greater tumour deformity which has developed rapidly. The radiographic appearance varies with the type of sarcoma. In some cases the bone is eroded, but the erosion is not confined to the vertebral body as is commonly the case with tubercle. The osteoplastic type of sarcoma shows an increase in the density of the involved bones.

b. In carcinoma there is often a history of a primary focus in the breast, prostate, thyroid, kidney, etc. The radiographs will show absorption of the bone calcium and an obliteration of the detail structure of the bone, suggesting that it is being gradually dissolved. As a rule there is no evidence of any new bone formation (*see Figs.* 563 and 564).

c. Osteomas may be multiple. The history shows that the tumour has been present for a long time and that its growth is slow. There is often no pain unless the osteoma interferes with other structures. The radiographs show that the bone structure of the tumour resembles that of normal bone (*see Fig.* 561).

5. *Aneurysm of the abdominal aorta* may rupture into the sheath of the psoas muscle and produce an abdominal tumour which on palpation may suggest a psoas abscess. A lateral radiograph of the spine may show the characteristic erosion of the vertebral bodies.

Figs. 542–547 illustrate the case of Miss M., age 17; photographs show the deformity produced by caries of the bodies of the 3rd, 4th, and 5th lumbar and 1st sacral vertebræ. The disease began six years ago.

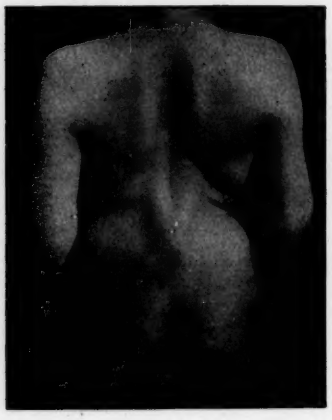


FIG. 542.

FIG. 543.

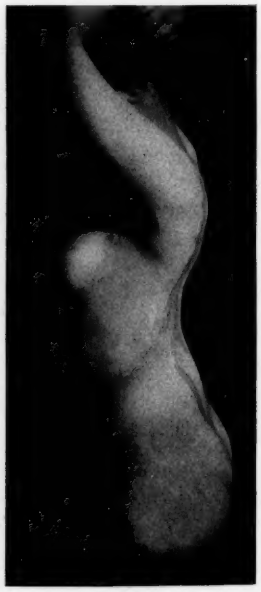


FIG. 544.

She was put on a straight frame for several weeks, and since that time has been allowed to walk about with a posterior support. It will be seen (*Fig.* 542) that the median furrow over the spine ends on a plane with the

FIG. 545.

FIG. 546.

FIG. 547.

iliac crests. Immediately below this is a median rounded swelling. Transverse furrows encircle the lumbar region just above the iliac crests. *Fig.* 543 illustrates the extent of flexion of the lumbar spine, and *Figs.* 544, 545 show how the lumbosacral angle has been obliterated and that the consolidated lower and sacral vertebræ are flat. There is no sign of spondylolisthesis. *Fig.* 546 is an antero-posterior radiograph taken three and a half years after onset of symptoms. It shows a crushing of the 3rd, 4th, and 5th lumbar vertebræ and erosion of the 1st sacral. Consolidation of the crushed bodies is taking place, and new bone union is seen between the right sides of the vertebræ, but fusion between the bodies has not occurred. *Fig.* 547 is a similar radiograph six years after onset. It shows complete consolidation of the involved vertebræ. Note the nerve foramina which have been formed in the new bone (cf. with *Fig.* 546).

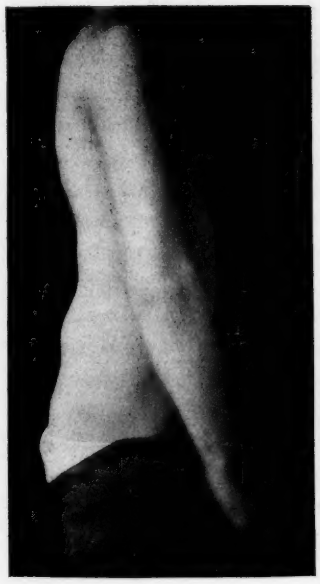


FIG. 548.

FIG. 549.

Mr. J. H., age 18, whose photograph and radiograph appear in *Figs.* 548, 549, began to complain of pain in the lower part of his back when 14 years of age. The pain radiated down both legs, and when 16 years of age was so severe that he was kept in bed. He was then X-rayed and put on a frame for

several months. He is now allowed to walk about with a posterior support.

FIG. 550. — Radiograph showing calcification in bilateral 'lumbar' abscesses associated with caries of the upper lumbar spine.

Fig. 548 shows a kyphos in the region of the lumbosacral joint; there is no external evidence of abscess. *Fig.* 549 shows caries of the 5th lumbar and 1st sacral vertebral bodies and a large abscess in the pelvis over the front of the sacrum in which some calcification has occurred. A collection of necrosed bone particles is seen in the lowest part of the abscess cavity.

The patient whose condition is illustrated by *Figs.* 551, 552 was a girl, age 6, who showed a definite kyphos deformity at the level of the 5th lumbar vertebra. Both figures demonstrate destruction of the 1st sacral body and part of the 5th lumbar by tuberculous caries. It will be seen that the spinous processes of these vertebræ are more prominent than those of the vertebræ above. There is some degree of spondylolisthesis.

Fig. 553 is a radiograph of Miss A. P., age 16, showing partial destruction of the 5th lumbar and 1st sacral bodies due to tuberculous caries which has produced a scoliosis. The patient began to have pain in the back and down the thighs after a fall seven years ago; no radiograph was taken at this time. After five years a left psoas abscess developed.

FIG. 551.

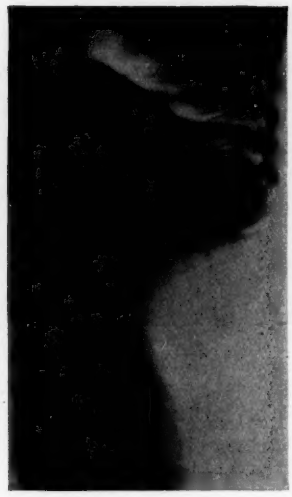
FIG. 552.

Fig. 554 is a radiograph of Miss A. C., age 32. It shows caries of the 2nd and 3rd lumbar vertebræ and 'crowding' together of the spinous processes of all the lumbar vertebræ. She gave a history of a fall which was followed by pain in the back and down the legs. The condition was diagnosed as lumbago and sciatica, and she was given massage. After twelve months a left

FIG. 553.

FIG. 554.

psoas abscess was detected and two years after this a lumbar abscess was found on the right side.



FIGS. 555, 556.—Lateral radiographs showing the marked lumbar lordosis due to destruction of the lower dorsal vertebral bodies by tuberculous caries.

Figs. 555–558 are further radiographic studies bearing on tuberculous disease of the spine.

Syphilis.—Changes in the spine due to syphilis are relatively infrequent. They may be seen associated with the development of: (1) Gummata; (2) Neuropathic arthropathy in tabes; (3) Aneurysm due to syphilitic aortitis.

FIGS. 557, 558.—Radiographs showing calcification of lymphatic glands, the shadows of which mask the right side of the lumbosacral joint and may lead to errors in interpretation.

Gummata.—The lesion produced by a gumma is usually rather different from that produced by tubercle, for while the latter is generally associated with bone atrophy and little new bone production, the gumma destroys the bone within its borders but gives rise to sclerosis and proliferation of the tissues surrounding it. Further, in my experience, a greater amount of what one might call 'symptomless bone destruction' may take place as a result of gumma: this may partly be due to preservation of the strength of the part by the surrounding sclerosis.

Only two cases with definite gummata involving the spine were seen. These were both located in the cervical spine. The radiographs of both showed destruction of the vertebral bodies with sclerosis and overgrowth of surrounding bone, and, after the administration of antisyphilitic drugs, fairly rapid consolidation of the involved vertebræ.

Another patient, age 46, had had a gumma of the testicle, and subsequently complained of pain in the lumbar region of the spine and down the thighs. He had a positive Wassermann reaction, and radiographs

(*Figs.* 559 and 560) show scoliosis of the lumbosacral spine with erosion of the opposing borders of the vertebral bodies on the concave side of the curvature, and dense sclerosis of the surrounding bone.

FIG. 559.

FIG. 560.

2. *Neuropathic Arthropathy of the Spine accompanying Tabes Dorsalis.*—Herndon, Buxton, Oberndorfer, Prokin, and others have reported instances of this condition. Herndon recently published the reports and a series of excellent radiographs of three cases which illustrate the X-ray appearances produced by the lesion. The radiographs of his first case show extensive destruction of the 5th lumbar vertebra and sacrum, with much new bone formation surrounding the lumbosacral joint. The radiographs of the second case show a lesion of the upper lumbar spine, but the destructive changes are not marked or typical. The radiographs of the third case show massive new bone formation around the 4th and 5th lumbar vertebræ. The clinical features of the cases are similar to those associated with Charcot's disease of other joints, with the addition of root pain due to involvement of the issuing nerves. Denuce describes a typical case of luetic spondylitis which gave the signs and symptoms of sciatic scoliosis.

3. *Aneurysm.*—Aneurysm of the abdominal aorta and iliac arteries may erode the lumbar bodies by constant pressure. Brailsford records a case of aneurysm of the abdominal aorta of a man, age 47, who for two years had complained of pain in the lumbar region which was treated as osteo-arthritis. Lateral radiographs show erosion of the upper three lumbar vertebræ, and the post-mortem specimen showed that the aneurysm had at some time perforated the sheath of the psoas on both sides.

Crisp described eleven iliac aneurysms in a group of 551, and points out that gluteal aneurysms may press on the sciatic nerve quite early in their development and cause pain, which may lead to a diagnosis of sciatica.

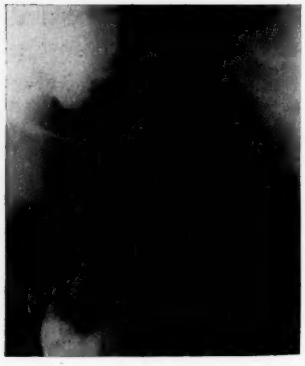


FIG. 561.

NEOPLASMS.

Osteomata.—These may be single or multiple, and produce deformity either by their size or by impingeing on other bony processes and thus causing erosion and curvature. Radiographs will demonstrate that the structure of the tumour resembles that of normal bone. *Fig.* 561 shows a large irregular exostosis on the right side of the lumbar vertebræ which is

articulating with the crest of the ilium. A second exostosis is shown to be growing from the left side of the pelvis in the direction of the lumbosacral joint. Galabin has described a large exostosis on the anterior aspect of the sacrum which gave rise to difficulty in childbirth.

Sarcoma.—Deformities due to sarcoma of the tissues in the lumbosacral region are not very frequent. They usually appear as rapidly growing solid tumours which have a smooth outline and are often associated with root pains. The radiographic appearance varies with the type of sarcoma. In one type the radiographs will show that the bony processes involved are eroded, and in others the involved processes are sclerosed. *Fig.* 562, a radiograph of a boy, age 16, shows increased density of the lumbosacral region of the spine due to a sarcoma which had eroded the upper posterior part of the sacrum.

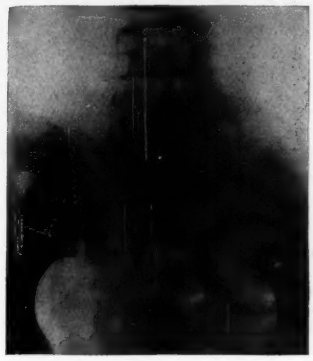


FIG. 562.

Brietländer describes an osteoplastic spindle-celled sarcoma of the 5th lumbar vertebra in a boy of 14. The radiographic illustrations show a dense structureless osteosclerotic 'marble' vertebra. He had neuralgic pains in both legs. Lipiodol was held up at the 1st lumbar vertebra. At operation a soft tumour was found in the spinal canal at the level of the 4th and 5th lumbar vertebræ. The 5th lumbar body was sclerosed peripherally, but the centre was hollowed out and filled with a soft tumour mass.

Carcinoma.—The commonest site for the development of secondary carcinoma in the bone is the lumbar region of the spine. Such secondaries are frequently seen from carcinoma of other organs, particularly the breast, prostate, kidney, and thyroid (*Figs.* 563–567). Occasionally no history of a primary growth is obtainable. Risley found that in carcinoma of the breast 25 per cent show

FIGS. 563, 564.—Radiographs showing complete disappearance of the 3rd lumbar vertebra secondary to carcinoma of the breast. Note that the 2nd and 4th lumbar vertebræ have only moved slightly from their normal positions and the alinement of the lumbar spine is practically normal.

FIG. 565.—Radiograph showing crushing of the 4th and 5th lumbar vertebræ secondary to carcinoma of the breast. Some degree of displacement of the lumbar vertebræ is suggested by the appearance of the 5th lumbar.

vertebral metastases. Levine says that his series shows that 53 per cent of breast carcinomata and 66 per cent of prostatic carcinomata have vertebral metastases. The tumour destroys the bone structure, the vertebral body collapses as a result of the superimposed body weight, and a kyphos deformity develops. If the lesion is associated with pain of sufficient severity to keep the patient in bed, the destruction of the bone will proceed, but as it is not subjected to the weight of the trunk above, no external evidence such as a kyphos may develop as the vertebræ preserve their normal position (*see Figs.* 563, 564). If there is no history of a primary tumour, the condition may be treated as a 'lumbago' or 'sciatica'.

FIG. 566.—To show changes in the 5th lumbar vertebra due to 'recent' invasion of the body by secondary carcinoma.

FIG. 567.—Crushing of the body of the 5th lumbar vertebra secondary to carcinoma of the sigmoid colon.

The X-ray appearances are typical. The bone has the appearance of being dissolved and crushed under the superincumbent weight, and there is usually no evidence of new bone formation (*see Figs.* 563 and 564).

BONE DISEASES OF UNCERTAIN ORIGIN.

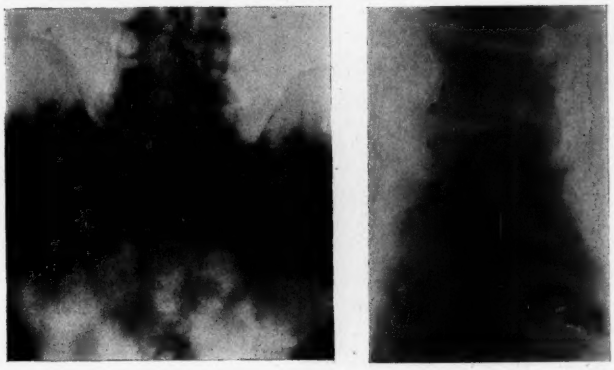
Paget's Disease.—Deformities of the lumbosacral region of the spine due to Paget's disease are only seen when the condition is advanced and the bones have softened and bent owing to the weight of the trunk. If the first bones to be involved are the sacrum or lower lumbar vertebræ, long before clinical signs are present which suggest the disease, the X rays will show the characteristic changes in the bones. The condition was recognized in twelve cases which had been X-rayed for osteo-arthritis of the spine or stone in the urinary tract.

In three cases the change in the bone was confined to the sacrum; in the others isolated lumbar vertebræ and parts of the pelvis also showed the change. Several of the patients complained of pain in the lumbosacral region of the spine which they attributed to injury.

X-RAY APPEARANCES.—The bones of the lumbosacral area which are involved appear to be a little enlarged in size. They are increased in density, and the structure of the lamellæ appears to be much coarser. Later the bones show irregular, ill-defined dense islands and 'bending' owing to the weight of the trunk on the softened bones.

The patient whose condition is illustrated in *Figs.* 568, 569 is a man, age 49. He complained of pains in the back and down the course of the sciatic nerve which commenced three months ago. He had several septic teeth and stumps.

The patient shown in *Figs.* **570, 571** said he was quite well until he fell into a hole 10 feet deep three years ago. Since then he has had pain in the lumbar region which has prevented him from working. The pain is increased by changes in the weather. Sometimes he is free from it for a week or so. He has tenderness over the 5th lumbar vertebra, and rigidity of the lumbar spine. He has many septic teeth. The radiographs show changes in the 4th lumbar vertebra and sacrum indicative of Paget's disease.



FIGS. 568, 569.—Antero-posterior and lateral radiographs showing Paget's disease of the sacrum.

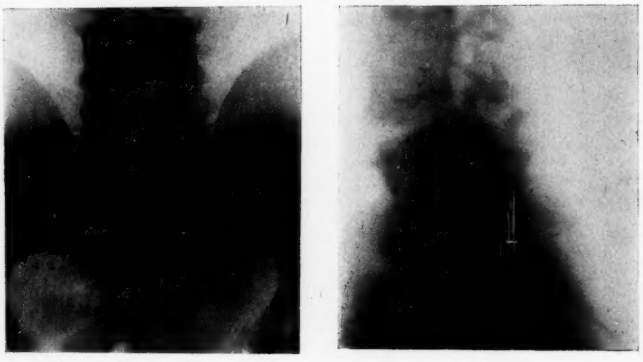


FIG. 570, 571.—Antero-posterior and lateral radiographs of a man, age 59, showing changes in the 4th lumbar and sacrum indicative of Paget's disease.

Fig. **572** is a radiograph of a woman, age 60, who complained of root pain in the lumbar region of the spine and pains in the legs. The duration was about one year, and pain more severe during the last month. The picture shows changes in the head of the left 10th rib, 12th dorsal and 1st, 4th, and 5th lumbar vertebrae, indicative of Paget's disease. Definite changes were also seen in the pelvis.

FIG. 572.

The history of the patient whose radiographic appearances are seen in *Fig.* **573** was that he had had pain in the back and legs for seven or eight years. During the last three or

FIG. 573.—Radiograph of a man, age 60, showing marked irregular sclerosis of the lumbosacral region of the spine suggestive of Paget's disease.

four years he has presented signs indicative of tabes dorsalis. He had syphilis forty years ago. The limb bones showed no evidence of Paget's disease.

FIG. 574.

Fig. 574 is a radiograph of a woman, age 52, showing crushing of lumbosacral region and pelvis, with extensive changes in all the bones indicative of Paget's disease. She had had symptoms referable to the lumbar spine for eight years.

Osteomalacia.—Deformity of the lumbosacral region of the spine due to osteomalacia is caused by the compression of the softened lumbar vertebræ, sacrum, and pelvis. The weight of the trunk forces the lumbar spine and sacrum forward and all the pelvic bones bend under the pressure. The trunk is therefore shortened. This is shown by the transverse furrows which encircle the lumbar region. The compression of the pelvis and the projection of the lower lumbar vertebræ into the brim of the pelvis can be readily detected when taking the ordinary obstetric measurements. Two cases were seen, both in women :—

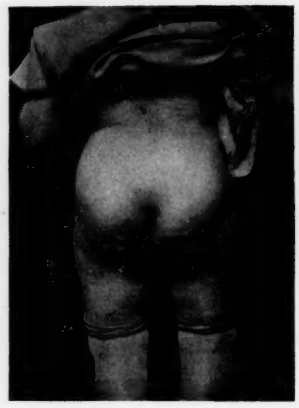


FIG. 575.

FIG. 576.

Case 1.—Married woman, age 50, had a spontaneous fracture of the right femur ; three months after, a fracture of the left femur. The radiographs showed that the bones of the pelvis were atrophied and distorted. The femora showed what appeared to be atrophy of the compact bone ; the outer quarter inch of the shaft cast a lighter shadow than the inner. Six months later the radiographs showed an increase in the density of the extreme periphery of the femora : this increase progressed, and after twelve months the compact bone appeared to be normal ; the femora appeared thicker than normal. Since the last fracture, calcium lactophosphate and pituitary extract had been administered for one year. No fracture has since occurred (six years).

Case 2.—*Figs.* 575, 576 are photographs of Miss S., age 23. She appears to have been quite healthy until the age of 15, since when

FIG. 577

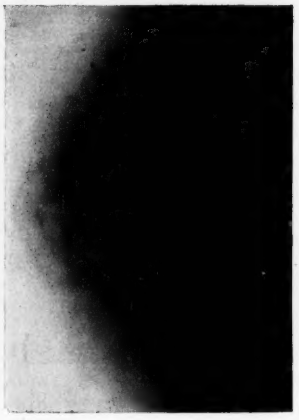


FIG. 578

she has not grown but has become stouter, her legs have bent, and her lumbar spine appears to have been crushed. The radiographic appearances are seen in *Figs.* 577, 578. The former is an antero-posterior view showing compression of the lumbar spine and sacrum into the pelvis. *Fig.* 578 is a lateral radiograph showing extreme folding of the sacrum and forward projection of the lumbar spine into the pelvic brim.

Figs. 579–582 are photographs of the 'Broughton' pelvis—a specimen in the Museum of the Royal College of Surgeons. It was removed from the body of a woman, age 31, who had died after Cæsarean section. Previously she had had five normal labours, but within the last four years she had lost four inches in height. A full clinical history is given in the records of the Museum.

FIG. 579.

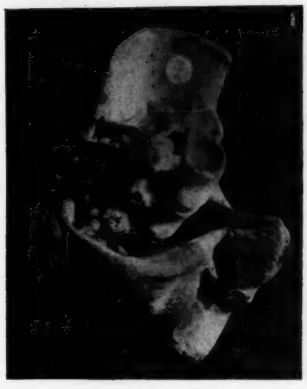


FIG. 580.

FIG. 581.

FIG. 582.

FIGS. 579–582.—The 'Broughton' pelvis. Note the marked forward projection of the lower lumbar spine and sacrum into the brim of the pelvis and bending of the pelvis.

CONCLUSIONS.

The following conclusions are the results of the foregoing investigations :—

1. That developmental irregularities of the lumbosacral region of the spine may be present without giving rise to symptoms. The type and relative frequency—26·4 per cent of the series examined—of these must be appreciated in interpreting radiographs of this region, and a careful investigation into all possible causes of the symptoms of which the patient complains should be made before attributing the symptoms to such an irregularity.

2. That the most frequent deformity associated with a developmental

irregularity is the scoliosis due to asymmetrical sacralization of the 5th lumbar transverse process.

3. That the deformities due to developmental irregularities which alter the alinement of the vertebræ tend to become more pronounced with age.

4. That the characteristic indication of spondylolisthesis on an antero-posterior radiograph is the continuity of the outline of the transverse processes and the anterior border of the body of the 5th lumbar vertebra. The absence of this in the radiographs of some of the published cases suggests an error in diagnosis.

5. That spondylolisthesis is a relatively rare deformity.

6. That the prominent ' knuckle ' deformity when present is often due to the projection of the 5th lumbar spine and not the upper border of the sacrum.

7. That a study of the specimens and radiographs of cases of spondylolisthesis negatives the suggested possibility of manipulative reduction of the displacement.

8. That spondylolisthesis occurs in children of both sexes, sometimes without symptoms, and that if due to trauma, the injury must have been in early life.

9. That severe trauma to the lumbosacral region in the adult can occur without producing spondylolisthesis.

10. That the consolidation which follows the treatment of tuberculous caries of the lumbosacral region of the spine obliterates the lumbosacral angle and reduces the possibility of spondylolisthesis.

11. That radiographs may not show any evidence of injury to the lumbosacral region until organization and calcification of the damaged structures have taken place, after which the radiographs taken at intervals show an increase in the deformity.

12. That symptoms and deformity following injury to the lumbosacral region in which osteo-arthritic changes have occurred may be more pronounced than would be expected from the degree of trauma.

13. That carcinoma and Paget's disease of the lumbosacral spine produce definite changes in the bone which can be recognized on a radiograph before any clinical deformity is apparent, and that the pain associated with these conditions may be referred by the patient to a recent injury.

I wish to express my thanks to Mr. Naughton Dunn, who suggested that I should undertake this investigation, and to whom I am indebted for referring to me many of the most interesting cases ; to Dr. J. C. Brash, Dean of the Medical Faculty and Professor of Anatomy, University of Birmingham, for permission to use the specimens in his department and for much valuable information and literature ; to Sir Arthur Keith for permission to investigate and photograph the specimens in the Royal College of Surgeons Museum ; and to my colleagues on the staffs of the Queen's Hospital, Birmingham, the Warwickshire Orthopædic Hospital, the Royal Cripples Hospitals, St. Chad's Hospital, Carnegie Infant Welfare Hospital, and the Ministry of Pensions Hospitals, Birmingham, for their help and permission to include their patients.

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TWO CASES OF CARCINOMA OF THE APPENDIX.

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THE following two cases of carcinoma of the appendix are of interest. In both the discovery of the growth was accidental.

Case 1.—O. M. S., female, age 14½ years, was admitted to hospital on Aug. 26, 1927, and diagnosed as suffering from acute appendicitis. The clinical report is as follows (R. C. M.):—

HISTORY.—Nine days before admission the patient was seized suddenly with acute abdominal pain on the right side. The pain continued intermittently. She vomited two days after the commencement of the pain. The bowels were constipated, but were opened with an enema two days before admission to hospital.

ON EXAMINATION.—The child looked ill. The temperature was 100·6° and the pulse 112. There was a large tender mass in the right iliac fossa.

OPERATION.—Right pararectal incision. The extraperitoneal tissues were very œdematous. On opening the peritoneum a large abscess was found,

FIG. 583.—*Case* 1. Appearance of removed appendix.

well shut off from the pelvis but extending upwards towards the liver. A large drainage tube was introduced and no attempt made to find or remove the appendix. The patient made a good recovery.

Second Operation (Sept. 29, 1927).—The original wound was excised and

the rectus muscle split, and on opening the peritoneal cavity the appendix was presented in the wound, being surrounded with omentum. The appendix was removed and a small drain inserted. The patient made an uneventful recovery, and is quite well at the time of writing. On examination the appendix was found to be somewhat pale and short, and at its distal extremity a small nodule was felt.

FIG. 584.—*Case* 1.

PATHOLOGICAL REPORT (A. G. S.).—

Macroscopical Appearances (*Fig.* 583).—The appendix presented a swollen and thickened appearance with some injection of the vessels. On section most of the proximal portion of the lumen was patent, but at the junction of the first and middle thirds the lumen ceased, becoming occluded by a solid yellowish growth which moderately distended the middle third of the organ. Where this growth ceased, the appendix was markedly constricted, but opened out to form a small circular cyst in the distal third. The walls of this cyst were infiltrated by the yellow neoplastic growth.

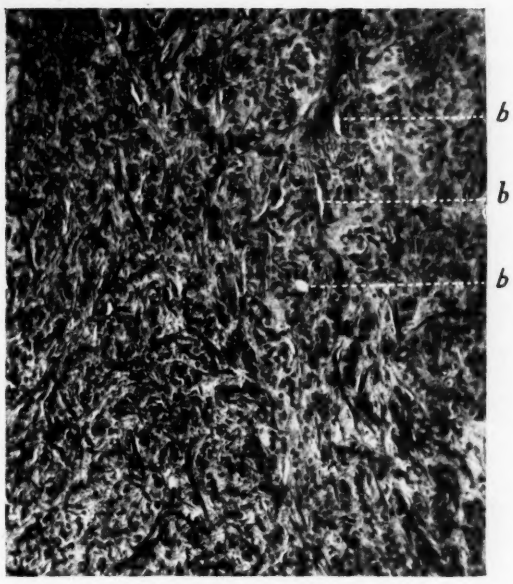

FIG. 585.—*Case* 1.

Microscopical Appearances.—Under the low power, alveoli of large and varying size are seen, consisting of closely packed masses of cells with a tendency to columnar palisading at the periphery, and here and there suggestions of lumina occur (*Fig.* 584, *a*). These should be noted carefully. The matrix is composed of fibrous tissue. This was scanty amidst the compact masses of cells, but more plentiful at the growing edge, where the tumour is infiltrating in a typically malignant invasive manner (*Fig.* 585). A few ill-formed lumina are visible in the infiltrated area (*b*).

Case 2.—Mrs. D. B. S., age 22, was admitted to hospital on Oct. 27, 1927. The clinical report is given below (R. C. M.).

HISTORY.—For the past ten months the patient had complained of pain, on and off, in the right iliac fossa. The attacks of pain were associated with nausea. On the day of admission she was seized with acute abdominal pain and vomiting.

ON EXAMINATION.—The temperature was 100·6° and the pulse 108. There was definite hyperæsthesia and tenderness in the right iliac fossa and some rigidity of the muscles on the right side of the abdomen.

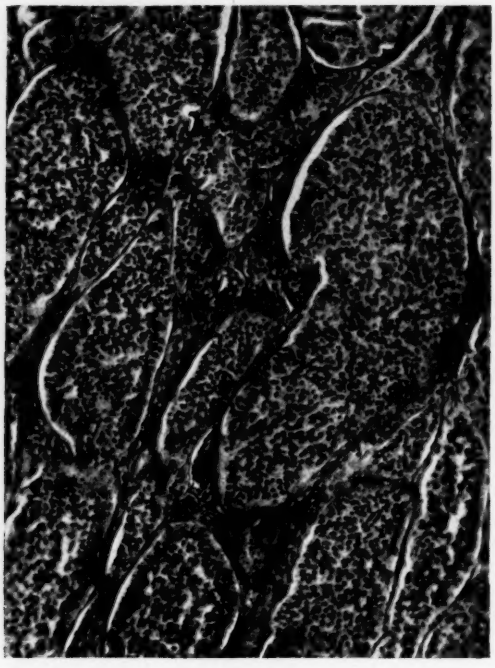

FIG. 586.—*Case* 2.

FIG. 587.—*Case* 2.

OPERATION.—Right paramedian incision. The appendix was found bound down by adhesions. It was slightly inflamed and at its top there was a definite hard swelling the size of a pea. The appendix was removed and a Lane's kink dealt with. The right ovary had on its surface a small papilliferous growth, which was excised. The patient made an uneventful recovery, and is at present fit and well.

PATHOLOGICAL REPORT (A. G. S.).—

Macroscopical Appearances.—The nodule of yellow growth in this instance was situated $\frac{1}{8}$ in. from the tip and was thus different in its locality from the specimen described in *Case* 1.

Microscopical Appearances.—The tumour is similarly composed of large alveoli containing compact masses of malignant cells. These are mainly spheroidal (*Fig.* 586). Less fibrous connective tissue is evident than in *Case* 1. Palisading at the periphery of the alveoli is quite definitely columnar, and two or three rudimentary lumina are visible. The edges of the tumour

show typical malignant infiltration. High-power magnification (*Fig.* 587) shows the type of cell to have large oval or rounded nuclei with well marked nucleoli and vacuolation (*v*).

COMMENTS.

There have been two papers relevant to these tumours in recent years, one in 1921 by D. P. D. Wilkie,[1] in which three cases are recorded and are described as 'typical spheroidal-cell carcinoma'. In all the carcinoma was situated near the proximal end of the appendix and yet gave rise to symptoms of obstruction. Wilkie gives the following features as typical of appendix carcinoma: (1) The early age incidence; (2) The spheroidal-cell type of growth; (3) The absence of metastatic glandular involvement. Our two cases agree, the ages being $14\frac{1}{2}$ and 22 respectively, the type of growth being similar, and, so far as could be discovered, there was absence of metastatic glandular involvement.

The second paper, by Ernest Shaw,[2] goes further in point of elucidation. He believes that the cells of which these tumours are composed are of a primitive fœtal type and they show attempted formation of typical epithelioid columnar cells, yet incompletely owing to weakness in developmental power. They multiply, but with the exception of a few which reach the columnar stage they seem incapable of attaining the higher type. Shaw quotes a case in which secondary growths occurred in the liver (Callender's case), having a cellular structure identical with this type of tumour. The appendix in this case showed a growth of a yellowish-white solid nature and was enlarged to the size of a tangerine orange. There is no doubt that the type of growth was similar and carcinomatous in nature.

Whereas the prognosis in the vast majority of cases is excellent, there is a very remote risk that if these tumours are not removed they may occasionally form metastases. This contingency is made further remote by the probability of the tumour giving rise to symptoms of appendicular inflammation, obstruction, or perforation, which subsequently (as in the two cases described) leads to removal of the organ.

It would seem that careful observation of the subsequent progress of these cases may throw light on the origin of carcinoma of the liver, and that some of the cases now diagnosed as primary in the liver may be found to be related to this apparently insignificant tumour of the appendix. Howbeit, neither of the aforementioned explanations of origin seems really satisfying. The matter has been settled by Masson in a very definite way and without any manner of doubt. There are certain cells to be found at all points of the intestinal lining, but especially at the base of the secreting glands, which are prismatic in shape with enlarged bases. These are known as the cells of Kutschitsky, and they have the peculiar property of containing granules having a marked affinity for silver nitrate (argentophil granules). Now, the peripheral palisading cells in particular and also many of the others in these appendix carcinomata have precisely the same specific property. Masson[3] illustrates this point in his book very beautifully, and there is no manner of doubt that these cells do originate the appendix carcinomata we have

discussed. It will be noted that this inference gives one more blow to the Cohnheim 'rest' theory so far as this particular tumour is concerned.

No one who has read Shaw's paper can reasonably doubt but that Callender's case of liver metastasis from one such tumour is genuine, and, indeed, after perusal of this paper further views as to the origin of these secondary deposits appear to be superfluous.

It is of the utmost interest for pathologists to examine critically every case of metastases in the liver for a possible appendicular origin, as this question of metastasis requires additional confirmation and undoubtedly does rarely occur, and it is with the object of stimulating interest of surgeons and pathologists to seek for definite confirmation of this point—namely, by finding secondary metastases in the liver showing the argentophil staining —that this paper has been written. If, indeed, such confirmation is to hand, the writers would keenly appreciate communications on the subject.

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[1] WILKIE, D. P. D., *Brit. Jour. Surg.*, 1920–21, viii, 392.
[2] SHAW, ERNEST, *Ibid.*, 1925–26, xiii, 130.
[3] MASSON, *Diagnostics de Laboratoire*, 1923, xxvii, 397 and Plate VI.

DIAPHYSIAL ACLASIS (MULTIPLE EXOSTOSIS) IN INDIANS.

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REPORT OF A CASE.

The patient was a Hindu male of about 28 years, a Sadhu by caste, and a non-vegetarian. He was admitted on Dec. 9, 1926, into King George's Hospital, Lucknow, for joint pains producing difficulty in movement during the previous two months, also for breathlessness, cough, and slight fever for six months. He died in hospital on Jan. 12, 1927.

History.—The history was unreliable. The patient stated that the joints of the lower limb and the right wrist had become swollen and painful after an attack of dysentery two months earlier. Before that he could walk and run like other men. He had a penile sore and a penile discharge six months previously. He said that his father had had syphilis, and that both parents died of cholera. He had not noticed the bony enlargements round his joints, and stated that none of his near relations had bony projections round their joints. He lived in Bilaspur until 12 years of age, in Ajudhia until he was 14, and in Hardwar until he was 21. None of these are endemic-goitrous areas. He had never had a goitre.

On Admission.—The patient was thin and weak. Weight 83 lb., height 5 ft. 3 in., chest (nipple level) 30 in., abdomen (umbilicus) 26 in.

Locomotor System.—On examination the curious bony projections round both knee- and ankle-joints attracted immediate attention (*Figs.* 588–590). These projections gave the region of the knee-joints an elongated appearance, and an apparent shortening and lateral curvature to both tibiæ. On closer examination irregular projections from uniform enlargements of the upper and lower extremities of the tibia, fibula, and femur, symmetrical on both sides, could be made out, but the main enlargements were round the knee-joints—that is, at the region of maximum growth of the leg bones. One projection on each side, in the region of the adductor tubercle, was especially marked. In the upper arm the expansion of the bony extremities was less marked, but was again observable at the ends where growth is greatest—that is, at the shoulder- and wrist-joints. The carpal, tarsal, metacarpal, metatarsal, and phalangeal bones were in the main unaffected, but one or two bony nodules could be felt at the base of the metacarpals and metatarsals.

The pelvis seemed unaffected except for an obvious nodular lipping along the outer margin of each iliac crest. In the shoulder-girdle a similar

nodular lipping existed along the vertebral border of the scapula, and to a less degree along the scapular spine. The coracoid process was enlarged on both sides. The bony wall of the chest showed two marked changes: the left tenth rib was markedly expanded throughout its whole length; and there were nodules where the costal cartilages joined the bony ribs, giving the appearance and feel of a rickety rosary. The hand and face bones were

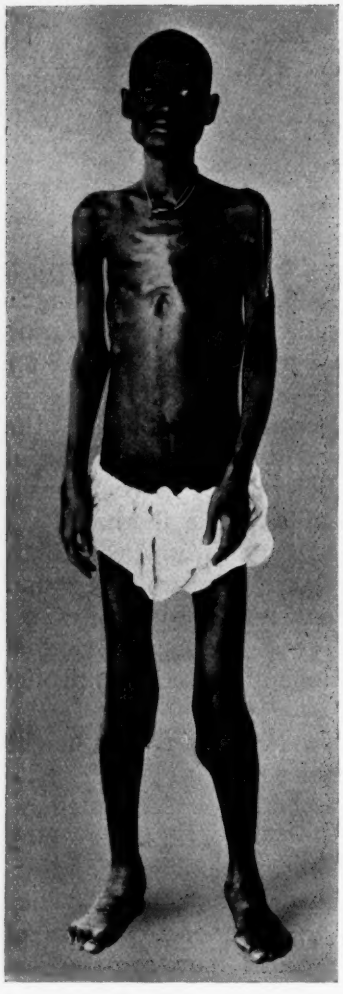


FIG. 588.—A case of diaphysial aclasis. The patient three months before death.

FIG. 589.—Composite X-ray photograph of same patient. (*By Dr. Raghunandan.*)

FIG. 590.—Skeleton of the same patient.

unaffected, as also was the spine, except that the posterior processes of the 7th cervical and 1st dorsal vertebræ seemed unduly prominent.

None of these bony growths, of themselves, limited the joint movements, but there was some slight swelling of the right ankle and to a more marked degree of the right wrist which was considered to be of a totally independent nature, either post-dysenteric or possibly tuberculous. No urethral pus could

be expressed, and no gonococci were detected in the prostatic secretion. An average of several total blood-counts worked out at 8080 white cells per c.mm., with a differential count of 65 per cent polymorphonuclears, 32 per cent lymphocytes, 2 per cent large mononuclears, and 1 per cent eosinophils.

Respiratory System.—Both lungs showed signs of diffuse bronchopneumonia. Tubercle bacilli were present in the sputum. There were no dull areas. The temperature showed an evening rise to 99° or 100°; on only one occasion did it rise to 102°.

Alimentary System.—Normal, except that the spleen was enlarged to four fingers below the costal margin, and very hard in consistence. The enlargement was probably malarial, though no parasites were found in the peripheral circulation.

The Circulatory, Nervous, and Endocrine Systems.—Showed no marked abnormalities.

Genito-urinary System.—The urine was normal. The blood serum was positive to the Wassermann reaction, completely deviating 3 and 5 (but not 8) minimum hæmolytic doses of complement.

The treatment adopted was for tuberculosis and syphilis, but the patient went downhill rapidly and died after some five weeks in hospital.

POST-MORTEM.—This was made within two hours of death. The alimentary, excretory, circulatory, and nervous systems showed no special abnormalities.

Respiratory System.—The right pleura was adherent over the upper lobe; left pleura adherent over the diaphragm. Right lung (12 oz.) studded with tubercles; left lung (14 oz.), lower lobe, studded with tubercles. Root glands enlarged and caseous.

Hæmopoietic System.—Spleen (20·5 oz.) greatly enlarged and fibrotic. Capsule thickened.

Endocrine Glands.—Pancreas, 3 oz.; thyroid, 25 grm.; thymus could not be traced; suprarenals—right 3·55 grm., left 2·55 grm.; pituitary, 0·5 grm.; pineal, 0·2 grm.; testicles—right 34 grm., left 21 grm.

COMMENTS.

The bony condition is typical of what was formerly described as 'multiple exostosis', now known under the more modern term of 'diaphysial aclasis'. The condition is definitely removed from the category of bony tumours, and is due to a growth disorder of cartilage, whereby the cancellous bone laid down between the diaphysis and epiphysis is imperfectly modelled by its lateral periosteal covering.

The shafts of long bones grow by two distinct processes: (1) New cancellous bone is first laid down at the shaft extremities in the diaphysial line. Achondroplasia results when this process is defective. (2) In the second or modelling process, this cancellous bone is absorbed and gradually converted into the compact shaft bone with its medullary cavity. In diaphysial aclasis all long bones exhibit one and the same defect, namely, arrest of the modelling process. Hence the several outgrowths of cancellous bone, which especially arise where growth is most vigorous and prolonged, as this case well illustrates.

This disease does not arise in membrane bones (e.g., the face bones or skull vault) or in bones formed in cartilage (e.g., the sternum, vertebræ, skull bone, carpal and tarsal bones, and epiphysis of long bones), but only in situations where the two processes of membranous and cartilaginous bone formation come into juxtaposition—especially, as in this case, where such a modelling growth is most marked (e.g., the diaphysial growing ends of long bone, the growing margins of the ilium and scapula, especially its vertebral border, the costochondral junctions, and both ends of the clavicle).

In the present case X rays show some abnormal periosteal deposit along the shaft of certain long bones. Bland-Sutton states that the bones are often abnormally thick. The disease usually starts in childhood and ceases with skeletal growth, and the probability is that this is what occurred in this patient. The diaphysial ends of the tibia and fibula are often fused, as in this case. Further, growth of the distal end of the ulna is deficient, whilst that at the distal end of the radius continues; whence the radius becomes 'bent to form a bow', the ulna serving as a 'stretched string'. The proximal end of the radius is sometimes dislocated and the external epicondyle of the humerus detached.

SIX FURTHER CASES IN INDIANS, WITH MARKED HEREDITARY HISTORY IN ONE FAMILY.

Since the foregoing case was written six further examples have come under our notice within six months, four (*Cases* 3–6) being in one family in which the hereditary history was marked.

Case 1.—An old woman, age 55 years, who came to hospital for gynæcological trouble. Large bony growths round both knee-joints were noted.

Case 2.—Sadika, Mohammedan female child of 8 years, with hard lumps noticed at the age of 1 year on the left wrist, and at the age of 7 round both knees. The wrist swelling was at first attributed to a fracture. All swellings have slowly increased in size, but cause no discomfort. The patient is anæmic and thin but not emaciated. Height 2 ft. 11 in., weight 37 lb. No evidence of congenital syphilis. The family history showed no similar condition amongst its members. Her father and mother are alive and healthy; two brothers and one step-brother are also healthy.

Position of Bony Outgrowths.—

Shoulder-joints: Upper ends of humerus on both sides are considerably thickened. Left scapula: Small nodule on vertebral border just below spine. Both clavicles showed small nodules at acromial ends. Elbow-joints: Small nodules on right olecranon process. Wrist-joints: Large projection of the left radius; small ones of the right radius and both ulnas (*Fig.* 591).

Hip-joint: The right great trochanter was slightly thickened. There were small nodules on both iliac crests. Knee-joints: Bony thickening on all sides of both joints (*Fig.* 592). Ankle-joints: Some nodules on both sides. Ribs: Small nodules about one inch from costochondral junction on the 5th to the 10th left ribs, and on 4th, 5th, and 6th right ribs.

Hands and feet, sternum, vertebræ, skull, and face bones were unaffected, and no abnormality was found in the respiratory, circulatory, alimentary, nervous, endocrine, and urogenital systems.

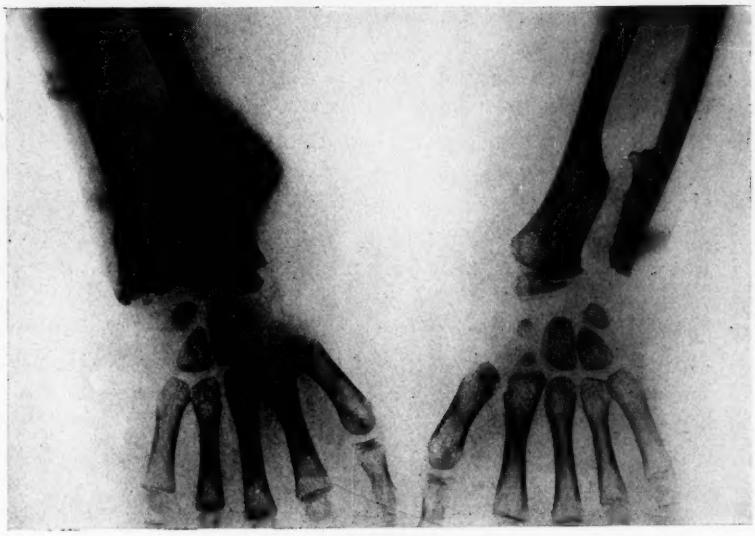


FIG. 591.—*Case* 2.

FIG. 592.—*Case* 2.

Case 3.—Syed Jawad, a Madrasi male, age 18 years, had bony growths round his knee, wrist, and shoulder, which he said had been present since

birth. These growths cause him no trouble; they have never been painful or tender, and he is able to cycle comfortably and well. The tumours gradually enlarged in proportion to his body growth, but have not been growing lately. No venereal history. Lymph glands, thyroid, and spleen normal; all systems normal. Height 5 ft. 8 in., chest at nipple level 30½ in., weight 120 lb.

Position of Bony Outgrowths.—

Around both knee-joints, especially at the lower end of both femurs, with marked projections 2½ in. above the joint. Also expansion of the upper end of both tibias and fibulas. (*Fig.* 593.)

At the lower end of the radius on the right side, the added bone being mainly about 2 in. above the wrist. At the proximal end of the left humerus, just below its head (*Fig.* 594). The lower half of the left border of the scapula shows marked thickening.

The costochondral junction of the left 6th rib shows marked thickening. Carpal, metacarpal, and phalangeal bones are free, as also are the ankle-, hip-, and elbow-joints.

Case 4.—Syed Husain, brother of *Case* 1, a schoolboy, age 12. Enlargements date from birth. Suffers no inconvenience.

Position of Bony Outgrowths.—

Around both knee-joints. The lower ends of both femurs are enlarged, and bony projections also arise from them, mesially as well as laterally, the latter being more prominent. The largest outgrowth is at the upper end of the right tibia, but both tibia and fibula are affected. (*Fig.* 595.)

Above both wrist-joints, especially on the volar surface of the radius 1 in. above the joints. The lower end of the left radius is also enlarged and the epiphysis is deformed. Below the head of the left humerus is a small nodular growth. The sternocostal junctions of the 5th and 6th ribs show small bony nodules.

Case 5.—Sister of *Case* 1, age 28, unmarried. We were ourselves unable to see this case and *Case* 4 owing to 'pardah'. They were, however, examined by a lady student of our college.

Position of Bony Outgrowths.—

Dorsal surface of the left radius 3 in. above the wrist. External surface of the 7th right rib, the size of an almond, 3 in. from the sternum. Anterior surface of the right clavicle, 2 in. from the sternal end.

Case 6.—Sister of *Case* 1, age 14.

Position of Bony Outgrowths.—

Dorsal surface of the right radius 2 in. above the wrist—small. Anterior surface of the left clavicle 2 in. from the sternal end.

Family History of the Cases 3–6.

There is a marked family history connecting these cases in two brothers and two sisters with their near relations. They belong to a family of sixteen children, two others of whom are known to be diseased. Of nine brothers in this family, four were affected. All sixteen are the children of one mother;

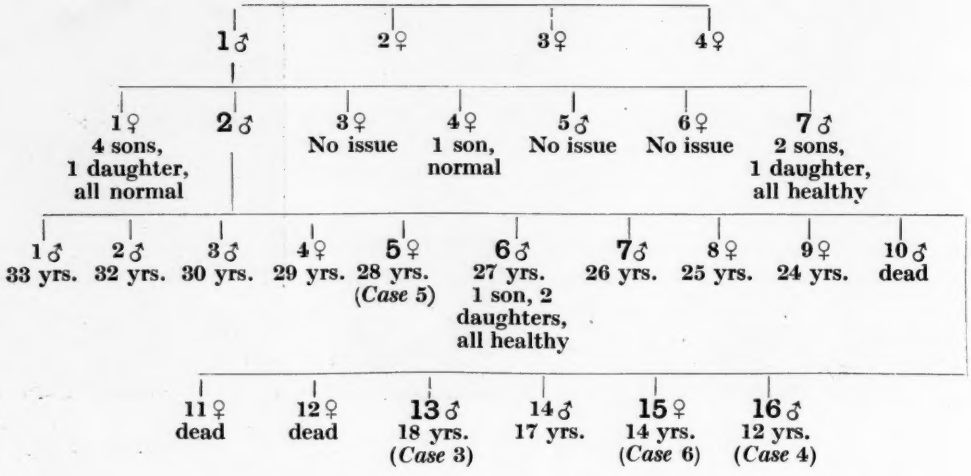
FIG. 593.—*Case* 3.

FIG. 594.—*Case* 3.

FIG. 595.—*Case* 4.

both she and her family were healthy; but the father and grandfather were affected (*see* Chart). The father was one of seven children—three males, of whom two were affected, and four females, none of whom was affected. There is no history of any other relations suffering with this trouble. The family state that a distant ancestor on his death-bed said that bony outgrowths would be a future characteristic of his family, and that this would be transmitted through his sons.

The Family Tree: Diseased Members are shown in Heavy Figures.



Children Nos. 13 (*Case* 3), 16 (*Case* 4), 5 (*Case* 5), and 15 (*Case* 6) have already been described. There remain Nos. 6 and 7. No. 6 is said to have bony outgrowths round both knees that are larger even than those of *Case* 1, but he can cycle without trouble. No. 7 has also big outgrowths round the knees. Possibly some of the children that are described as healthy have small outgrowths which would not be missed on medical and X-ray examination.

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THE REMOTE RESULTS OF GASTRECTOMY.

FROM THE WARDS OF THE MIDDLESEX HOSPITAL:

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AND R. VAUGHAN HUDSON, *Assistant Surgeon to the Hospital.*

FROM THE COURTAULD INSTITUTE OF BIOCHEMISTRY:

BY E. C. DODDS, *Professor of Biochemistry in the University of London, Chemical Pathologist to the Middlesex Hospital;*
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FROM THE BLAND-SUTTON INSTITUTE OF PATHOLOGY:

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INTRODUCTION.

THIS investigation is the work of three different groups of workers, each group independently submitting its report on the completion of the whole series. It was only when the investigation was finished that the clinical, biochemical, and bacteriological results were compared. In this paper are considered the remote results of gastrectomy only. Precise operative technique, immediate mortality, and post-operative treatment have not been dealt with; nor have the theories of the causation of ulceration, and the relative merits of the various other types of surgical operations performed for the relief of benign ulceration of the stomach and duodenum, been discussed. The paper is divided into four sections—historical, clinical findings, laboratory findings, and, lastly, the commentary which expresses the considered opinion of the three groups of workers.

THE HISTORY AND EVOLUTION OF THE OPERATION OF GASTRECTOMY FOR PEPTIC ULCER.

RESECTION OF THE STOMACH IN ANIMALS.

Although a research into the literature has revealed the fact that experimental gastric surgery existed prior to 1810, nevertheless Merrem,[1] in his "Inaugural Dissertation" in this year, appears to have been the first to report the resection of a portion of the stomach in dogs, and it is interesting that one of his animals survived for twenty-seven days. It appears that this communication escaped general notice, and it was not until 1874 that the real foundations of gastric surgery were laid by the considerable experimental work of Gussenbauer and Winiwarter,[2] who worked with dogs in Billroth's clinic in Vienna. Their research was undertaken in order to find the best method of coaptation of the unequal segments resulting from removal of the pyloric end of the stomach. The junction was commenced by performing

a preliminary suture, sometimes of the greater, sometimes of the lesser curvature of the stomach, and was completed by a circular suture of the duodenum to the thereby narrowed gastric segment. The modern surgeon still appreciates the difficulties accompanying this anastomosis. In 1875 Klemensiewicz[3] attempted a partial gastrectomy in dogs: he made two parallel incisions across the pyloric portion of the stomach and converted the tubular piece removed into a blind fistula opening on to the abdominal wall; the continuity of the remaining stomach was restored by suturing the cut end of the duodenum to that of the fundus of the stomach. By this means he obtained a tube of the pyloric portion of the stomach, and, although the animals died within some five days, he was able to establish the fact that the pylorus secreted an alkaline fluid containing pepsin. Heidenhain,[4] using the antiseptic methods of Lister, repeated these experiments in 1878, and was able to keep the animals alive for periods of up to five months. He did little more, however, than confirm Klemensiewicz's original observation concerning the alkalinity of the pyloric secretion and its pepsin content. In the same year Kaiser[5] published an account from Czerny's clinic; he reviewed the literature concerning operations on the stomach in animals and in man, and described in detail total gastrectomy in dogs. These experiments seem to have been commenced about the year 1875, since he reports that in 1876 a dog was gastrectomized successfully and was still living at the time of publication. Kaiser laid great stress upon the after-treatment of the dogs, which were fed on very small quantities of milk and minced meat at first, since otherwise vomiting occurred. It is interesting to note that the weight of the dog before gastrectomy was 5850 grm., and that in some seven months it had risen to 7000 grm.; by this time the animal was able to feed normally. The after-effects of these procedures may be judged from the very interesting paragraph in one of Bunge's[6] lectures :—

> In Leipzig, in the year 1882, Ludwig and his pupil Ogata were engaged in investigating the functions of the stomach. It occurred to them that it would be interesting to learn what had become of Czerny's dogs. Ludwig wrote to Czerny at Heidelberg, who answered by sending the dog in a perfectly healthy state to Leipzig. It was in excellent spirits and ate all kinds of food with a keen appetite. The fæces were normal. In consequence of the abundant food it put on weight, and it did not appear to differ in any way from an ordinary dog. With Czerny's consent the dog was killed in the spring of 1882. "The post-mortem showed that only a very small portion of the cardiac end of the stomach remained, and this was dilated into a small cavity filled with food." *The dog had therefore lived for more than five years without a stomach.*

In the year 1883 Ogata,[7] wishing to avoid the elaborate surgical technique of the earlier investigators, decided to study the problem anew by producing a duodenal fistula. Through this he introduced an indiarubber ball attached to a piece of tube into the pyloric portion of the stomach; the ball was distended with water so as to shut off the stomach. Food substances were then introduced into the efferent loop of the duodenum and the effect on the animal was studied. Ogata noticed that if food had been boiled for a prolonged time it reappeared in the fæces almost unchanged; connective-tissue residues were also present in the fæces.

De Filippi[8] in 1894 published two papers concerning the metabolism of

dogs gastrectomized by Monari. The investigations, which do not appear to be very extensive, are mainly a confirmation of Ogata's findings: he found that the digestion and the absorption of food substances were fairly complete, except that the fæces contained undigested residues, and that there was a considerable loss of fat by this route. That intestinal putrefaction was greater than normal was shown by the presence of indican bodies and an excess of ethereal sulphates in the urine, which was also found to contain an excess of urobilin. Apart from this, the communications contained no new points.

Carvallo and Pachon[9] in 1895, working on a cat, found that it could continue a normal existence after gastrectomy, and on post-mortem examination no abnormality was found in the tissues; the cat, however, did not take food when this was offered, but had to be coaxed to eat. Contrary to the findings of Ogata in dogs, the cat was able to digest connective tissue. In the report of the post-mortem[10] these authors state that histological examination proved conclusively that the whole of the stomach had been removed—a condition never attained in the dog. They conclude that, although the stomach is not essential for digestion, it may play an important part in the sensation of hunger, and they suggest that the lack of appetite in their cat was due to the absence of a stomach to contract and give rise to hunger pains.

In 1896 Monari[11] published a fairly full account of his work on resection of the stomach in dogs. The physiological and biochemical work on his animals was done by De Filippi, as has already been described. There is a good summary of the literature in this paper, but unfortunately no references are given. One point of interest noted by Monari was the hypertrophy and dilatation of the œsophago-jejunal junction whereby a considerable reservoir for food was formed. He noticed that the animals vomited at first if ordinary food was given to them, but after a few weeks of careful feeding this ceased. The cause of death in some of the animals was attributed to starvation, and there was no mention of anæmia in any of the dogs operated upon.

Carrel, Meyer, and Levene[12] investigated the nitrogenous metabolism of gastrectomized dogs, and came to the conclusion that there were no noteworthy differences from the normal.

RESECTION OF THE STOMACH IN MAN.

A careful study of Billroth's publications shows that the possibility of removing the human stomach for malignant disease was ever in his mind, and he approached the subject logically, step by step. Thus, the cure of a gastric fistula described in 1877[13] proved to him that the human stomach could be sutured without digestion of the stitches taking place. At the end of this paper he remarked upon the successful results of his pupils Gussenbauer and Winiwarter in their animal experiments; this knowledge, together with that derived from his successful suture of the human stomach, convinced him that gastrectomy in the human subject should be possible in the near future. He said: "It only requires a bold step forward from this operation to achieve the resection of a portion of the stomach affected by carcinomatous degeneration." In the year 1879[14] he discussed the successful resection of intestine, and the reader gathers that he had definitely made up his mind

with regard to human gastrectomy, for, instead of saying that the operation would be "a bold step", he said: "It must succeed, though of course one ought to begin with a simple and not too extensive case."

The first account of gastric resection in man was given by Péan[15] in 1879. He described a pylorectomy performed by him for a tumour of the pyloric end of the stomach, discovered at operation to be freely mobile. The patient, in spite of three blood transfusions, died on the fifth day. On Nov. 16, 1880, Rydygier[16] performed a pylorectomy, but the patient died twelve hours later. He published another paper in 1881[17] claiming to be the first to perform a premeditated resection of a gastric carcinoma.

In January, 1881, Billroth performed the first successful pylorectomy, and on Feb. 28 and March 12 of the same year he repeated the operation but without success, the third operation being effected by a modification of the original method: the particular technique employed in this third case is now known as the Billroth I method. Stieda[18] states that at the very moment that Billroth's assistant Mikulicz was reporting the first three operations of pylorectomy at the 10th Congress of German Surgeons on April 8, 1881, Wölfler at Billroth's clinic was performing the fourth gastric resection by the Billroth I technique, and this case was also brought to a successful issue. At this meeting, Rydygier, although he hotly claimed to have been the first to carry out deliberately the operation of pyloric resection, acknowledged the priority of Péan, who was forced by necessity to resect a pylorus. Despite the claims of Rydygier, however, one must hail Billroth as the founder of gastric surgery, for it was the experimental work of the assistants in his clinic on animals, and the surgical work on gastric suture in human beings performed by himself, that paved the way for modern technique. Rydygier[19] was, however, the first to perform a pylorectomy successfully for a benign ulcer, and in this communication he describes the indications for the operation, the technique, and the post-operative dangers. In a later paper[20] he gives a summary of his successful cases.

In 1883 Billroth introduced the technique of the Billroth II anastomosis, and this was described in detail by von Hacker[21] in 1885. It would appear from the literature between 1881 and 1883 that of 25 cases recorded by Billroth, 20 died—a mortality of 80 per cent. In 1898 Hartmann[22] unsuccessfully used the end-to-side gastrojejunal modification of the Billroth II operation, but the method passed temporarily into disrepute since Eiselsberg, Roux, and Doyen also had unsuccessful cases. The operation was revived again by Reichel[23] in 1908 at the 38th Congress of German Surgeons, and in 1911 Pólya[24] published his method of partial gastrectomy; this method to-day is widely known, but few realize that the loop was retro- and not ante-colic. In Germany and Austria the names of Hofmeister and Enderlen are both associated with Pólya's technique.

Moynihan[25] describes two cases of complete gastrectomy performed by him during the year 1907. The first operation was for an hour-glass stomach and the second for malignant disease. From this time a series of papers have come from the Leeds school on the subject. The operation was adopted in England by Moynihan, Sherren, and certain contemporary surgeons, in the belief that some types of benign ulcers were pre-carcinomatous; although this

danger has been recently found to be much less than was at first thought, the operation had given such good results that this particular treatment for benign ulcers was continued.

In 1916 Bland-Sutton[26] described the results of 20 cases of pyloric and pyloroduodenal resection for pyloric and duodenal ulcer, the first of these operations having been performed in 1909. It is, however, to Finsterer, Haberer, Clairmont, Riedel, and Payr that the credit is due of having established a safe operative technique for the removal of duodenal ulcers, and gastroduodenal resection for this disease has now been performed some thousands of times on the Continent and also, though much less often, in this country.

THE REMOTE RESULTS OF GASTRIC RESECTION IN MAN.

The after-effects of gastrectomy on patients were investigated in 1894 by Langenbuch,[27] who described the effect of removal of the stomach for carcinoma in a woman of 58, and also from another woman of 56. The writer concludes that the stomach can be removed without serious detriment to the individual. It is interesting to note that he emphasizes the importance of a minimum amount of anæsthetic being used.

Schuchardt[28] in 1895 described the survival of a case of gastrectomy for two and a half years. He records the interesting observation that although the patient could eat only small quantities of food at first, his capacity gradually increased. Practically the whole of the stomach had been removed to within three finger-breadths of the œsophageal orifice, and it was found that the upper part of the junction had dilated to 500 c.c. capacity.

A very careful and full account is given of a patient operated upon by Schlatter[29] working in Krönlein's clinic. The operation was performed for carcinoma of the stomach in a woman of 56. The writer describes a complete gastrectomy in which the pyloric end of the duodenum was ligated and the junction completed by an œsophago-enterostomy. The stomach was sent to Professor Ribbert for examination, and this pathologist reported that the cut ends were proved histologically to be composed of œsophagus and duodenum respectively; in other words, the gastrectomy had been complete. The patient made a good recovery and gained 4·4 kilo. in weight. In order to make the investigation complete, Wroblewski was called upon to make a thorough biochemical examination one month after the operation, and his report was published in 1897.[30] Daily analysis of the urine did not show anything remarkable except that indican bodies were present in many of the specimens; the fæces showed about 40 per cent of fat. An examination of the vomit of the patient showed a total acidity of 34, and a large amount of lactic acid was present. Free hydrochloric acid was found in very small amount, and the general conclusion was that the patient was in normal health. In his own paper Schlatter describes the literature fairly fully, and discusses the bearing of his case and the observations of Wroblewski upon the current views as to gastric function. His conclusions are best expressed in his own words: "The stomach is principally a means of protecting the intestine, by preventing or diminishing those qualities which the food might have which

are injurious for the bowel. But the intestine is fully capable of carrying out the chemical work of the stomach upon suitable food."

In 1898 Hofmann[31] describes his investigation of Schlatter's case three months after operation. He paid special attention to the amount of ethereal sulphate bodies present in the urine, and he showed that even five months after operation the amount excreted was fairly normal. The clinical condition of the patient also seemed very good.

A very valuable contribution to the literature was made by Deganello in 1900[32], in which he describes a series of most careful and complete investigations on a patient operated upon by Tricomi.[33] The patient was a woman, age 48, whose stomach was removed almost completely 'pour cancer diffus'. For the first seven days following operation the patient was nourished by the rectum, but after this liquid foods were given by mouth and included soup, milk, marsala, and eggs. Deganello then proceeded to analyse all the food given to the patient and to analyse the urine and fæces. By this means he was able to study the exact amount of digestion and metabolism that was taking place. It would be impossible to deal adequately with the great amount of work appearing in this valuable paper, and the conclusions only can be stated here. Deganello proved that the digestion and absorption were comparable to normal. At first there were large quantities of ethereal sulphates present in the urine, demonstrating excess of intestinal putrefaction; as time went on, however, the quantity of these substances fell. Examination of the fæces showed the constant presence of intact muscular fibres. Withdrawal of a specimen through the œsophagus showed that it was only slightly acid, but no mention is made as to whether the fluid was tested for free hydrochloric acid. Perhaps the most striking point of Deganello's paper is his report on the blood of the patient. Some three months after the operation the hæmoglobin was found to be 65 per cent and the number of red cells 3·67 million; he states that the film was normal and that there was no alteration in the shape of the corpuscles. This appears to be the first reference in the literature to a hæmatological examination being made in these cases. This brilliant publication is brought to a close with a brief discussion as to the probable functions of the stomach. The author points out that the only noticeable feature about this case was the excess of intestinal putrefaction, and since this gradually diminished as time went on, he concluded that a compensatory process was at work. In his own words: "In this case a wonderful compensatory process is built up in virtue of which the organism gradually adapts itself to such greatly altered conditions of life."

Since certain types of anæmia are associated with disturbances of the gastric secretion, it is not surprising that some of the observers have stated that diseases of the blood may follow removal of the stomach. In 1903 Grawitz[34] maintained that there was a causal relationship between achylia and severe secondary, and even pernicious, anæmia. It has long been known that pernicious anæmia is always accompanied by achlorhydria: it is therefore necessary to consider very carefully the hæmatological picture in cases that have undergone gastrectomy. Recorded cases of true pernicious anæmia as a sequel to gastrectomy are very few in number. Moynihan[35] describes a case of severe anæmia occurring in a patient whose whole stomach had been

excised for scirrhous carcinoma; the patient lived for three years and eight months after the operation, but became progressively more anæmic and emaciated during the last year of life. At the necropsy there was no evidence of any malignant recurrence, and death was attributed to severe anæmia. This case, however, lacks many of the essential features for establishing a certain diagnosis of true pernicious anæmia; no blood-counts are recorded; at the necropsy the long bones were not examined, nor was the liver tested for free iron. Hartman[36] also describes a case of gastrectomy for carcinoma in which, prior to operation, there was achlorhydria with a low total acidity. Eighteen months after the operation the patient was pale and anæmic, and two years and ten months after gastrectomy the blood-count was as follows: hæmoglobin, 48 per cent; red cells, 1·42 to 1·88 million; colour index, 1·2 to 1·6; anisocytosis is said to have been moderate and was associated with a slight degree of poikilocytosis and polychromasia. A point in favour of the diagnosis of pernicious anæmia as a consequence of gastrectomy in this case of Hartman's was the occurrence of remissions, though these were of shorter duration than is usually the case in this disease, but the final phases are not recorded. The blood-counts, though suggestive, lack the definite evidence of megalocytosis, and it is noteworthy that there was an initial achlorhydria. In the cases of both Hartman and Moynihan there was the underlying malignant factor to complicate the blood picture. Campbell and Conybeare,[37] in a review of 75 cases of Addisonian anæmia, include one patient upon whom a gastro-enterostomy had been performed for gastric ulcer, and who later developed a blood picture typical of pernicious anæmia. The case is merely recorded without comment. Of four other cases, mentioned by Hurst,[38] no full account can be found in the literature. Recently Lake,[39] Morley,[40] and Perman[41] have described the end-results of a series of partial gastrectomies; their findings are considered in the commentary.

THE SCOPE OF THE INVESTIGATION.

The work about to be described was commenced in January, 1928, and consisted in a study of 52 hospital patients, 14 females and 38 males. Whilst every care was taken to exclude patients suffering from malignant disease in this series, two of the cases eventually developed carcinoma and are dying from this disease. The operation of gastrectomy had been performed on all the patients in the series, which was a consecutive one, starting in the year 1921 and finishing in 1926. It follows, therefore, that the investigations were made at varying times from the date of the actual operation. The object of the research was twofold: first to contrast the pre-operative and post-operative conditions of the patient from as many points of view as possible, and secondly to determine what effect the removal of part or the whole of the stomach had upon the digestion, metabolism, intestinal flora, and composition of the blood. In addition to the points already mentioned, the examinations were so extended as to embrace systems other than the alimentary: all cases were especially investigated to ascertain whether the pancreas, colon, or liver had been affected by the removal of the stomach. These findings can be considered under two headings—'clinical' and 'laboratory'—and will be dealt with separately.

CLINICAL FINDINGS.

Type of Case.—The great majority of the lesions were gastric ulcers; a certain number were duodenal ulcers, and a few gastrojejunal ulcers. With one or two exceptions these ulcers were not free, but were adherent to one or more of the structures in the neighbourhood. The operation performed varied with the lesion; in the majority the resection was completed by a retro- or an ante-colic anastomosis performed after the Pólya or Pólya-Balfour method. In the early cases the original Pólya technique was used; later the modification advocated by Moynihan of a short ante-colic loop was employed; but since 1924 a longer ante-colic loop has been adopted. In the earlier cases of resection for gastrojejunal ulceration, an anastomosis-en-γ was performed; the later cases were treated by Finsterer's method—namely, restoration of the normal continuity of the small intestine and a retro-colic anastomosis of the stomach to the jejunum.

Amount of Stomach Removed.—It is always difficult to assess the amount of stomach removed in the operation of partial gastrectomy. The proximal portion of the stomach lies in the recess formed above and in front by the diaphragmatic cupola and costal margin, and behind by the depression which arches steeply from the spinal column. When the stomach enlarges—for example, in pyloric stenosis—this increase in size occurs principally in the pyloric antrum. These two factors tend unwittingly to lead both the surgeon and the onlookers into the belief that a larger portion of the stomach has been removed than is actually the case. If an opportunity should occur to observe the condition shortly after a gastric resection has been performed, it will be seen that a surprisingly large amount of stomach still remains even in those cases in which the resection has been thought to approach a total gastrectomy. It is probable that in the great majority of partial gastrectomies one-third of the stomach is left, and in some cases more than this remains.

Trauma to the Neighbouring Tissues.—

The Omentum.—In the earlier cases the greater arterial gastric tributaries to the omentum were ligated. In the later cases the individual omental vessels have been tied close to the stomach in order to preserve as much blood-supply to the omentum as possible. No detrimental changes have been observed due to wholesale ligation, but it is felt to be more rational to obviate as many sources of omental damage in benign ulcers as possible.

The Pancreas.—Nearly all the ulcers dealt with were adherent to or burrowing into the pancreas. Many of the ulcers were removed together with their base of pancreatic tissue; in other cases the ulcer base was left behind and cauterized with pure carbolic acid. In these particular cases no evidence of pancreatic disease has been found. There is, however, no doubt that pancreatic trauma should be particularly avoided, and that a certain percentage of the immediate mortality may be attributable to this factor.

The Biliary Tract.—In a few cases a cholecystectomy was performed at the same time as the gastric resection, owing either to the presence of gall-stones or to the adherence of this viscus to the ulcer. In none of these cases, nor in those patients with an intact gall-bladder, have there been any symptoms referable to the biliary tract.

The Appendix.—In those cases in which it was considered advisable, the appendix was removed at the time of the operation.

Estimation of the Results of Gastric Resection upon the Patient.—The estimation of the results of gastric resection upon an individual may be gauged in several ways: the expression of the patient himself is of value and his general clinical appearance of great help. It would appear, however, that the most valuable comparison is that of the social and economic activities of the individual before and after the operation, and, when it is wished to apply a single expression of comparative value, the post-operative capacity for work is the best. Those patients who are able to do full-time work without undue fatigue, who eat a normal diet, and enjoy good health, are designated 100 per cent efficient. Patients working part-time only, or whole-time light duty, and taking restricted diet, are considered to be 50 per cent efficient.

Table I.—Investigation of 68 Cases of Gastric Resection.

Year of Operation	Number of Patients Fully Investigated	Number Interviewed and Clinically Examined, but who Refused Further Investigation	Number of Patients not Interviewed but whose Fate is Personally Known and Verified
1920	5	2 (both 100 per cent)	
1921	5		
1922	5		2: (*a*) 100 per cent, now in Australia. (*b*) 100 per cent until 1926, when he died of phthisis
1923	6	1 (100 per cent)	2: (*a*) 100 per cent, now in South Africa. (*b*) Dying from carcinoma ventriculi with multiple secondaries; ulcer was reported as benign
1924	12	3 (all 100 per cent)	2: (*a*) 100 per cent until killed in street accident in 1928. (*b*) 50 per cent until he died in 1928 of a chest complaint (? T.B. ? pneumonia)
1925	5	1 (50 per cent)	
1926	14	3 (2 were 100 per cent, 1 was 50 per cent)	
Totals	52	10	6

In *Table II* can be seen the results of gastric resection on efficiency, based upon capacity for work and social activity. In the pre-operative columns it can be seen that three-quarters of the patients were completely incapacitated, whereas the post-operative column shows that this figure has been reduced to a minute fraction of the total number of cases. Similar results are also shown with the lesser degrees of incapacity prior to operation.

When the results in women are compared with those in men it is seen (*Table III*) that nearly all the males are 100 per cent efficient, whereas less than three-quarters of the female patients come under the same category. None of these patients has had illness of any sort since the operation. From *Table II* it can be seen that 3 per cent only are totally incapacitated, and one of these is a male who recently died in his home of what may have been a gastrojejunal ulcer, but was possibly carcinoma. The other is a female in whom we are at present unable to discover any organic lesion, but this

has certainly been an unsatisfactory case from the time she left the hospital until the present moment. This table also shows that of the four patients who are performing light work only, three are women. In two of these, both of whom had had severe hæmatemesis, a prepyloric ulcer was found, and

Table II.—Percentage Results for the 52 Cases fully Investigated, on the Basis of Efficiency for Work.

Efficiency	Pre-operative		Post-operative	
	Number of Patients	Percentage of Patients	Number of Patients	Percentage of Patients
Nil	40	77	2	4
50 per cent ..	10	19	4	8
80 „ ..	2	4	0	0
100 „ ..	0	0	46	88

Percentage Results for 67 Cases (Excluding the Death from Malignant Disease.)

Efficiency	Pre-operative		Post-operative	
	Number of Patients	Percentage of Patients	Number of Patients	Percentage of Patients
Nil	54	81	2	3
50 per cent ..	11	16	7	10
80 „ ..	2	3	0	0
100 „ ..	0	0	58	87

in the third the operation was performed as an emergency for an acute hæmatemesis which proved to be due to gastrostaxis with an accompanying small chronic ulcer. The fourth patient is a male upon whom a gastrectomy was performed for a large perforated duodenal ulcer, and he suffers from attacks of epigastric pain of variable intensity and periods; he has also had one severe hæmatemesis either from an acute ulcer or of the nature of gastrostaxis.

Table III.—Post-operative Efficiency of Females as Compared with Males.

Efficiency	Females (Total Number 14)		Males (Total Number 38)	
	Number of Patients	Percentage of Patients	Number of Patients	Percentage of Patients
Nil	1	7	1	3
50 per cent ..	3	22	1	3
100 „ ..	10	71	36	94

Diet.—On discharge from hospital each patient was given a diet sheet and advised how to regulate his or her subsequent mode of life, but in no case were these instructions carried out apparently for any length of time. In spite of gastric resection the great majority possessed a good appetite and

partook of ordinary meals at the usual intervals. The meal interval averaged four hours, and the main intake was either at lunch or at dinner. On the whole it is quite evident that the size of the meals was in reality less than usual, and that bulky foods were avoided. Even those patients who partook of food every two or three hours made one meal their chief one, only taking a very light repast at other times. A large or bulky meal usually caused post-prandial distension, and many volunteered the fact that they had transferred their large meal to the evening when work was over, because they found that the rest after the meal aided digestion. The actual diet varied within wide limits, and many patients throve upon what would be considered entirely unsuitable. Raw, green vegetables in small quantities were usually enjoyed; mutton was always preferred to beef, and twice cooked food was avoided; few ate puddings of any kind, and the majority avoided sweet things. A certain number were entirely unable to eat eggs, although prior to the operation they had enjoyed them. Often alcoholic drinks, mild beer or stout, appeared to be an asset and aided the digestion; spirits, particularly in the form of whisky, disagreed. All the patients stated that, although for some months after the operation they had maintained a fairly rigorous diet with small intervals between the meals, they were gradually able to take larger and larger meals with lessening intervals between, so that, about six months after the operation, a normal dietary was taken. Some volunteered the fact that their stomach seemed to stretch as time went on, and this is descriptive of a condition which has been verified by post-operative X rays—namely, that the portion of stomach left behind and the varying portion of the efferent loop of the jejunum undergo dilatation and hypertrophy.

Occupation.—Those patients classified as 100 per cent efficient were performing arduous work, many of them being occupied a great number of hours a day in heavy manual labour.

Gain in Weight.—The average gain in weight in this series was two stone, the least being a few pounds and the most four stone. This increase in weight is based upon the hospital weight prior to operation.

Return to Work.—The average period elapsing before return to full work was six months, the longest time being two years and the shortest five weeks after operation. This is shown in detail in *Table IV*.

Table IV.—Average Time of Return to Full Work.

Length of Time after Operation in Months	Number of Patients	Percentage of Patients
0–3	17	33
3–6	16	30
6–12	17	33
12–24	2	4

Clinical Examination (*Chart I*).—Clinically the gastrectomized patients may be divided into two main groups, a minor group of fat patients and a larger group of thin ones. The few patients belonging to the former class consisted

CLINICAL

CASE	AGE	WEIGHT PRE-OP. STONES	WEIGHT POST-OP. STONES	OCCUPATION PRE-OP. EFFICIENCY IN %	OCCUPATION POST-OP. RETURN TO WORK. LIGHT	OCCUPATION POST-OP. RETURN TO WORK. IN YEARS FULL	PRESENT OCCUPATION	TYPE OF OPERATION	DIET	FOODS AVOIDED	APPEARANCE	POST PRANDIAL DISTENSION	BOWELS
1	32	GAINED 2½ ST.		50		3/12	TRAVELLER	EN.Y. TOTAL	NORMAL	PUDDINGS	NORMAL	+	D
2	49	11	10-12	0	4/12	5/12	BOOT REPAIRER	RETRO-COLIC	NORMAL	SWEETS	ICT.	+	N
3	57	6	7-5	0		3/12	HOUSEWIFE	EN.Y. TOTAL	NORMAL	TEA COCOA	PALE	+	N
4	62	7	10	0		12/12	HOUSEWIFE	ANT.-COLIC	NORMAL	SWEETS COFFEE	PALE	+	C
5	57	7	9	50		2/12	LAVATORY ATTEND.	ANT.-COLIC	NORMAL	NOTHING	PALE	—	N
6	54	7?	10-5	0		5/12	AUDITOR	TOTAL ANT-COL. *	NORMAL	NOTHING	NORMAL	—	N
7	44	8	11	0		3/12	BUS CLEANER	ANT.-COLIC *	NORMAL	NOTHING	NORMAL	—	N
8	58	8	9	0		6/12	WAITER	RETRO-COLIC *	NORMAL	BACON	FAT	—	N
9	36	9	9-10	0		3/12		RETRO-COLIC	NORMAL	NOTHING	NORMAL	—	N
10	47	7	7-12	0	3/12	NIL	LIGHT HOUSEWORK	ANT.-COLIC	MILK	IRREGULAR	PALE ICT.	+	C
11	46			0		3/12		EN.Y. HIGH RETRO-COL.	NORMAL				
12	47	9	9-3	0		5/12	BAKER	HIGH SLEEVE RES.	NORMAL	NOTHING	PALE	+	N
13	38	11	9-13	50	1/12	NIL	LIGHT HOUSEWORK	ANT. COLIC	NORMAL	SWEETS	PALE	+	N
14	29	7	9	50	12/12	24/12	BUS CONDUCTOR	EN.Y HIGH RET.-COL.	NORMAL	NOTHING	NORMAL	+	C
15	53	7-5		50	3/12	12/12	HOUSEWIFE	RETRO-COLIC	FISH	EGGS SWEETS	NORMAL	+	N
16	47	11-6	11-2	0		4/12	ELECTRICAL ENG.	RETRO-COLIC	NORMAL	SALADS	NORMAL	+	C
17	38	10-11	9-13	0		5/12	PAINTER	RETRO-COLIC	NORMAL	EGGS SWEETS	NORMAL	+	N
18	50	8	9-6	0		4/12	COAL SHOVELLER	HIGH RETRO-COLIC	NORMAL	NOTHING	NORMAL	+	N
19	52	7-4	7-8	50	2/12	18/12	CLERK	ANT. COLIC	NORMAL	NOTHING	PALE ICT.		N
20	34	7-11	9-4	0		6/12	MOTOR DRIVER	RETRO-COLIC*	NORMAL	EGGS BACON	NORMAL	—	N
21	35	12-3	13	0		4/12	COMMISSIONAIRE	RETRO-COLIC *	NORMAL(LARGE)	NOTHING	NORMAL	—	N
22	35	7	9	50		8/12		RETRO-COLIC	NORMAL	SWEETS	NORMAL	+	D
23	37	9-7	10-9	80	4/12	6/12	SIGNALLER	RETRO-COLIC	NORMAL	EGGS MEAT	NORMAL		N
24	45	8?	8-3	0	3/12	4/12	HOUSEWIFE	ANT-COLIC	MILK FISH		ICT.	+	C
25	43	11	10-5	0	6/52	2/12	ENGINEER	RETRO-COLIC	NORMAL	NOTHING	NORMAL	+	N
26	51	8-5	9-10	0		24/12	LABOURER	TOTAL ANT-COLIC	NORMAL	NOTHING	PALE ICT.	+	C
27	33	6	9	0		2/12	FRUITERER'S ASSIST.	RETRO-COLIC *	NORMAL	NOTHING	NORMAL	—	N
28	32	7	10	0		6/12	SALESMAN	EN.Y TOTAL RET.-COL.	NORMAL	PORK STEAK	NORMAL	—	N
29	59	9	9	0	12/12	NIL		ANT. COLIC	LIGHT		PALE ICT.	+	D
30	57	10	10-2½	50		3/12	BUTLER	RETRO-COLIC	NORMAL	MEAT FISH	NORMAL	+	C
31	41	8-2	10-2	0		2/12	ENGINE FITTER	ANT. COLIC	NORMAL	EGGS	NORMAL	+	N
32	25	9	10-2	0		3/12	CLERK	RETRO-COLIC	NORMAL	VINEGAR PICKLES	NORMAL	—	N
33	58	8	11-6	50		6/12	HORSEMAN	ANT. COLIC	NORMAL	NOTHING	FAT	+	N
34	57	6	10	0		8/52	PORTER	HIGH RET.-COL. *	NORMAL	NOTHING	NORMAL	—	N
35	34	10-10	10-6	0		3/12	UNEMPLOYED	ANT. COLIC	NORMAL	NOTHING	NORMAL	+	N
36	44	6	ABOUT 8	0	4/12	6/12	HOUSEWORK	HIGH ANT.-COLIC	NORMAL	NOTHING	PALE	—	C
37	28	9-8	9-9	0		3/12		HIGH RET.-COLIC	NORMAL	NOTHING		—	N
38	37	9-4	9-4	0		12/12	FARM LABOURER	ANT. COLIC	NORMAL	NOTHING	NORMAL	—	N
39	51	9-2	12-13	0			ENGINEER	ANT. COLIC	NORMAL	SWEETS	NORMAL FAT	—	N
40	41	10-7	10-2	0		6/12	HOUSEWORK	ANT. COLIC	NORMAL	NOTHING	NORMAL	—	N
41	56	6-10	6-13	0	NIL	NIL	HOUSEWORK	ANT. COLIC	FISH	MOST FOODS	PALE	—	D
42	56	12-2	11-8	0		8/12	LABOURER	HIGH ANT.-COLIC	NORMAL	PORK	NORMAL	+	N
43	40	10	10-12	0		2/12	CLERK	ANT.-COLIC	NORMAL	EGGS CHEESE	PALE	+	D
44	44	8?	10-2	0		5/12	SHOP ASSISTANT	HIGH ANT.-COL. *	NORMAL	NOTHING	NORMAL	—	D
45	39	9-4	9-11	80		2/12	SHOP ASSISTANT	ANT. COLIC	NORMAL	MILK FLUIDS	PALE	+	N
46	33	9-8	11-8	0		2/12	PAINTER	SCHUMACHER	NORMAL	NOTHING	NORMAL	+	C
47	60	GAINED 1 ST.		0	21/12	NIL	HOUSEWORK	ANT.-COLIC	LIGHT	EGGS FATS	FAT	—	N
48	29	10	11	0	12/12	NIL	HAIRDRESSER	ANT.-COLIC	LIGHT	IRREGULAR	PALE	+	N
49	57	7	8	0	6/52	6/12	FULL HOUSEWORK	RETRO-COLIC *	MILK	FISH MEAT	FAT	+	N
50	36			0		3/12	MENTAL NURSE	ANT.-COLIC	NORMAL	NOTHING		—	C
51	42	7-8	7-8	0	3/12	12/12	HOUSEWIFE		NORMAL	SWEETS	PALE ICT.	+	C
52	46	9-2	8-6	50		6/12	HOUSEWIFE	HIGH ANT.-COLIC	NORMAL	EGGS GREENS	PALE ICT.	+	N

Chart I.—Type of operation : * Ulcer base left on pancreas and carbolized.
Appearance : Ict. = icteroid.
Bowels : D = diarrhœa. N = normal. C = constipated.

of one or two men and several women; the men were elderly and the women middle-aged. The fat was not that of health but of the type associated with a sedentary life and a carbohydrate diet, though in these particular cases the diet differed very slightly from the normal. One or two women and the great majority of men gave the impression of being spare. A certain number of patients in both groups possessed a pallor which was greater than usual, and this was frequently accompanied by a slight icteroid tinge. A few had definite pallor with a tendency to blueness of the sclerotics and a definite conjunctival yellowish tinge; these cases were found to have an anæmia of the secondary type. It had been noticed that, during the early months after the operation, some patients developed what was recognized as 'the gastrectomy facies'. This manifested itself by the clinical signs of secondary anæmia and a peculiar appearance of the tongue. The tongue was somewhat pallid and slightly larger than normal; the mucous membrane was atrophic, but the individual papillæ were clearly recognizable and not absent. As the patient returned to full diet, in the great majority of cases the tongue became normal and the anæmia tended to disappear. (*Fig.* 596.)

FIG. 596.—The tongue of a patient six months after gastrectomy.

About 15 per cent of all the cases examined stated that they tired more easily than normally, but that they recovered rapidly with food and a short rest. It is interesting to note that, in spite of these findings, no case of illness of any sort has occurred among the patients since their operation. Time alone will reveal their ultimate condition.

LABORATORY FINDINGS.

FRACTIONAL TEST-MEAL.

The average emptying time of the stomach throughout the series was greatly reduced; it was less than one and a quarter hours in twenty-six cases, and over two hours in four cases only. These findings were corroborated by the early disappearance of starch from the gastric content. The resting juice was scanty, being usually under 10 c.c., and a considerable amount of bile was always present. The patients with an emptying time of under one

and a quarter hours usually complained of some post-prandial distension, but they were able to take a normal meal.

Free hydrochloric acid was found in 20 per cent of the cases in which a complete test-meal chart is available. Of the remaining 80 per cent, although showing achlorhydria, some possessed strong evidence of the secretion of acid by the stomach. It will be seen from the test-meal charts (*Chart II*) that the disparity between the 'free' and 'total' acid curves is great, and in no way resembles the type of curve found in pernicious anæmia. Practically all the cases showing the presence of free hydrochloric acid had an emptying time of

Table V.—Urinary Concentration in Cases with a Rapidly Emptying Stomach.

Emptying Time of Stomach in Hours	Percentage of Free HCl in Stomach	Specific Gravity of Urine	Total N_2 of Urine in Mgrm. per 100 c.c.	Urinary Chlorides in Mgrm. per 100 c.c.
1	Nil	1004	290	187
1	,,	1008	—	567
½	,,	1006	—	385
½	,,	1005	280	468
¾	,,	1005	333	585
½	,,	1008	—	538
1	,,	1008	—	428
1	,,	1002	200	305
1	,,	1004	240	256
1¼	,,	1003	210	230
1¼	,,	1008	300	223

Table VI.—Urinary Concentration in Cases with a Normal Emptying Stomach.

Emptying Time of Stomach in Hours	Percentage of Free HCl in Stomach	Specific Gravity of Urine	Total N_2 of Urine in Mgrm. per 100 c.c.	Urinary Chlorides in Mgrm. per 100 c.c.
2	18	1012	610	1176
2	50	1012	666	948
2	Nil	1018	960	567
1¾	,,	1014	520	672
1¾	12	1018	1150	680
1¾	10	1012	430	—
1¾	Nil	1019	870	1325
1¾	55	1010	660	724
2	12	1012	800	1065

over one and a half hours, and had less bile in the earlier specimens than did the cases showing achlorhydria.

The most noticeable feature in those cases possessing a rapidly emptying stomach was the copious amount of urine passed by them immediately following the test-meal. In the cases examined the patients were instructed to empty their bladder before the test-meal was administered. One hour after

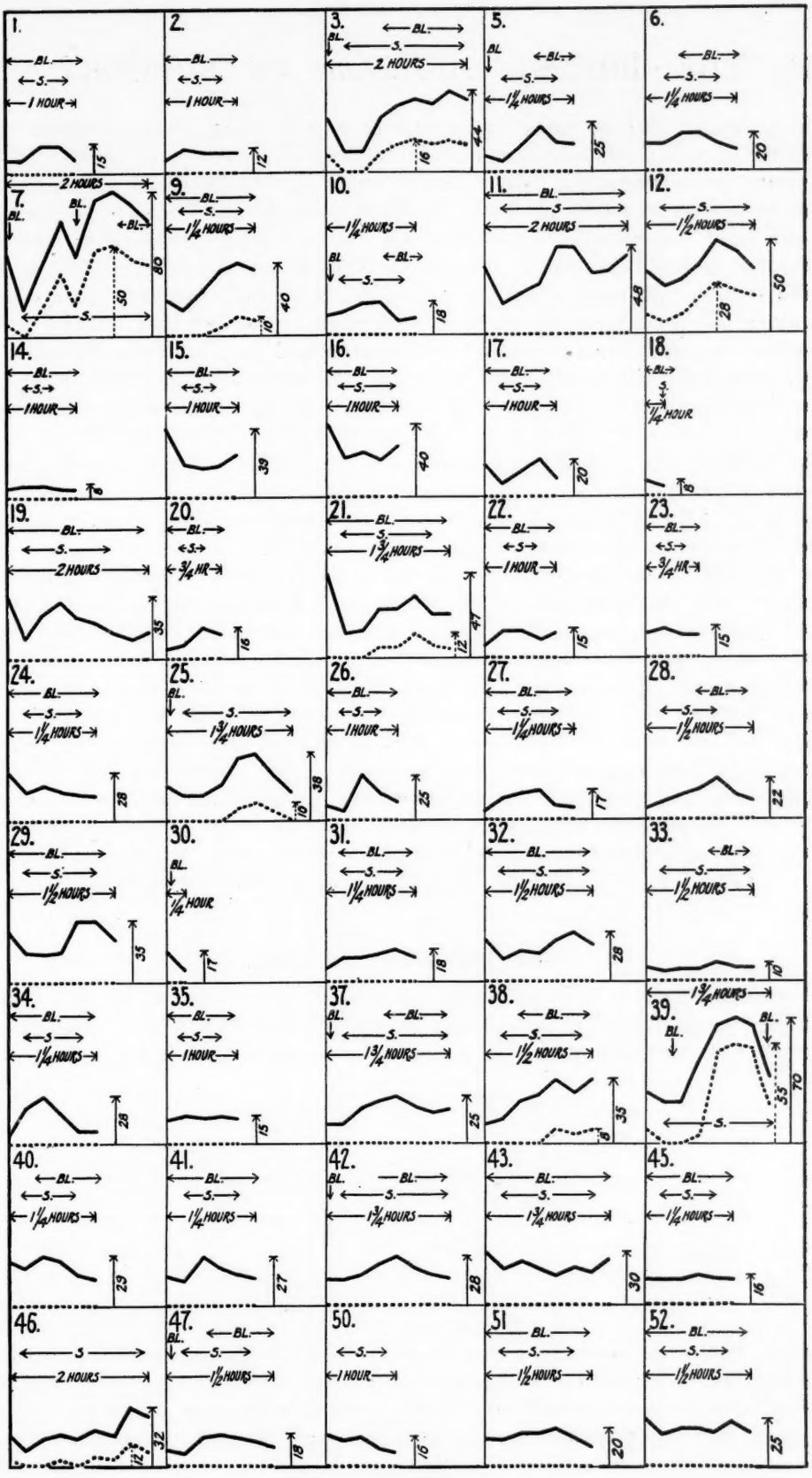

Chart II.

———— Total acidity expressed in c.c. N/10 NaOH per cent.

..... Free hydrochloric acid expressed in c.c. N/10 NaOH per cent.

S = starch present. BL = bile present.

taking the meal they were instructed to empty their bladder again. The volume of urine was measured and its specific gravity and total nitrogen contents were estimated. An examination of the whole series shows that it can be divided into two groups: (1) Those cases in which the specific gravity of the urine fell immediately after the test-meal; and (2) Those in which it remained roughly constant. The association of the specific gravity of the urine passed one hour after the test-meal, and the emptying time of the stomach, is very interesting, since it demonstrates the fact that the absorption of water is largely controlled by the rate at which it passes from the stomach to the small intestine. The rôle of the pylorus in controlling water absorption has been demonstrated under entirely different circumstances by Rowntree and his co-workers.[42] It is reasonable to assume that those patients showing a rapid emptying time of the stomach, and a rapid drop in the specific gravity of the urine, lacked that pyloric control which obtains in the normal person and in the other patients of our series with a long emptying time. *Tables V* and *VI* show this in detail.

Another noticeable feature in the patients with a rapidly emptying stomach was the large amount of gas removed with the resting juice and the later specimens of the meal. Whether the presence of gas in the stomach was due to aerophagy on the one hand, or to a fermentation on the other, it is not possible to say at this stage of the investigation. In the cases in which the emptying time was normal or increased, the presence of gas was not so noticeable; nor did these cases complain of so much post-prandial distension as did those in which regurgitation was marked. Also, there was not so much regurgitation of jejunal contents, and free hydrochloric acid was present. It would appear, therefore, that in these cases there is some control by the stoma, and as the presence of hydrochloric acid seems to depend on the degree of regurgitation, it is the rapid neutralization that is responsible for the apparent achlorhydria.

BLOOD EXAMINATION (*Chart III*).

Hæmatological.—A hæmoglobin estimation, a red and white cell count, and an examination of a film were made in each case of the series. For general purposes, where anæmia has been found, the cases have been divided into two

Table VII.—Degree of Anæmia.

	Number of Patients with Normal Blood-counts	Number of Patients with Mild Anæmia	Number of Patients with Marked Anæmia	Total Number of Patients Examined
Males ..	23	8	7	38
Females ..	6	0	8	14

groups, mild and marked. In the case of males (38 cases) the term mild anæmia has been used to designate all counts with the following features: hæmoglobin between 70 and 80 per cent; red cells between 4 and 4·9 million; or cases showing both these reductions. In the case of females (14 cases) a

BLOOD *IN mgrms PER 100cc.*														
CASE	UREA	N.P.N.	CREATININ	URIC ACID	SUGAR	CHLORIDES	CHOLESTEROL	CALCIUM	PHOS	FOUCHET TEST	RED CORPUSCLES IN MILLIONS	LEUCOCYTES IN THOUSANDS	HÆMO-GLOBIN %	COLOUR INDEX
1	29·2	27·2	1·1	5·6	124	468	228	11·1	3·55	—	4·9	5·4	88	·9
2	45	44	1·9		111	535	210	13·7	4·8	—	5·0	6·6	80	·8
3	31	40	1·7	4·1	130	461	148	8·6	4·5	—	5·4	8·8	86	·8
4		60		3·0	97	535	166	10·4	3·0	—	4·8	6·7	60	·6
5	30·9	25·9	1·5	4·4	114	468	205	13·4	3·0	—	4·2	4·8	88	1·0
6	24	23	1·7	3·5	91	490	230	10·3	2·5	—	5·2	10·6	88	·85
7	25·7	45	1·4	4·8	99	497	222	12·12	1·9	—	5·1	7·6	90	·95
8	37·9	34·1	1·4	3·1	82	695	188	11·4	3·3	—	4·6	6·2	60	·7
9	60	50	1·55	3·9	100	468	198	13·0	2·5	—	3·9	8·0	75	·9
10	24	23	1·55	3·4	95	550	210	10·6	2·5	—	4·0	10·2	79	·9
11	35	35	1·5	4·6	103	525		13·6	4·8	—	4·7	5·2	76	·8
12	20·4	40		4·7	115	467	155	11·1	2·0	—	4·1	4·8	78	1·0
13	24	26	1·4	3·2	100	585	152	11·0	2·5	+	5·2	10·8	36	·5
14	28	35		4·7	80	562	200	12·9		—	5·0	3·2	92	·9
15	30	26	1·25	3·0	105	495	235	11·2	3·9	—	4·8	7·0	70	·6
16	36·7	37		4·9	108	527	150	13·4	4·5		5·2	5·0	90	·9
17	33·9	28	1·5	3·9	103	530	174	12·8	2·5	—	4·3	8·4	85	1·0
18	38	35	1·6	7·1	100		105	12·5	2·5	—	3·4	5·6	85	1·2
19	18	19	1·4	3·5	80	620	170	11·6	2·6	—	5·0	6·6	85	·85
20	27	34	1·35	3·5	141	526	150	9·2	2·4		4·2	9·0	40	·5
21	35·7	31	1·4	4·8	114		186	13·1	5·1	—	5·2	9·6	82	·8
22	25·7	28	1·45	4·4	114	568	253	9·5	3·3	—	5·2	14·0	62	·6
23	39	34	1·6		110	596	175			—	5·0	5·6	90	·9
24	28·9	38·1	1·85	3·0	168	573	245	12·6	2·6	—	4·1	7·0	55	·6
25	35·7	33	1·5	4·1	91	485	110		4·5	—	4·8	7·0	96	1·0
26	26·8	33·3	1·1	2·7	138	514		8·8	1·9		4·9	3·4	70	·7
27	32	44	1·6	3·8	114	545	180	13·6	4·7	—	6·3	5·6	82	·7
28	31	30		3·9	94	505	213	13·0		—	5·3	10·8	92	·9
29	36·6	28	2·0	4·5	130	460	103	13·1	2·1		5·5	5·2	75	·6
30	32	34	1·6	4·1	117	475	148	11·8	3·5	—	5·1	6·0	92	·9
31	24	25	1·55	4·75	100	480	232	11·4	3·0	+	5·1	7·0	85	·85
32	33·7	33		6·0	107	540	165	12·3	2·5	—	4·4	5·6	85	1·0
33	32	35	1·3	3·2	109	421	166	13·4	3·5	+	3·6	5·2	80	1·15
34	26	27		5·5	93	505	200	9·6	4·2	—	5·6	3·4	84	·8
35	29·2	26·5	1·66	3·7	91	425	184	10·5	2·6		5·4	6·0	90	·85
36		59		2·2	119	632	164	11·3	2·2	—	3·9	3·3	25	·35
37	24	36·3		3·2	147	515	155	10·9	2·0		5·7	5·2	45	·4
38	24	31	1·35	4·3	181	484	176	10·7	2·1		4·3	10·4	85	1·0
39	30	38·5	1·8	4·0	115	456	140	11·5	1·5		5·3	8·4	96	·9
40	24·5	32·5	1·3	4·0	70	538	188	9·9	1·8	+	3·7	6·8	47	·63
41	20	25·6	1·1	3·8	120	495	288	10·5	1·95		4·1	6·4	72	·9
42	23	29	1·5	5·6	136	538	250	12·6	3·0	—	5·0	7·0	78	·8
43	21	19·5	1·2	5·3	128	503	250	10·6	3·4	—	5·3	10·8	76	·75
44	39·2	40·	1·7	2·7	130	432	87	12·4	1·8		5·4	6·8	62	·6
45	27	23	1·4	4·6	101	515	240	11·2	2·8	—	6·1	8·6	80	·7
46	22·2	28·6	1·1	2·3	143	526	145	10·2	1·8		4·6	4·6	76	·8
47	24	20	1·6	3·4	98	503	222	10·6	3·5	—	4·6	5·0	88	·9
48	27	33	1·5	4·0	97	471	188	13·4	4·5	—	4·7	12·0	80	·9
49	31	31	2·0	6·0	129	496	213	10·3		—	4·9	8·0	84	·8
50	27·2	31	1·45	3·4	137	503	164	10·0	2·4		6·3	4·6	70	·6
51	40	30·6	1·4	3·2		585	189	13·0	2·6	—	3·7	5·8	38	·53
52	30·5	24·5	1·75	3·0	115	595	214	10·3	2·6	—	3·9	5·0	36	·45

Chart III.

blood estimation showing hæmoglobin between 65 and 75 per cent, red cells between 3·7 and 4·4 million, or both these features, has been classed as mild anæmia. Any diminution in hæmoglobin or red cells beyond these figures has been grouped as marked anæmia.

Hurst, as already pointed out, has maintained that Addisonian anæmia sometimes follows gastrectomy and gastro-enterostomy, and we have searched for confirmation of his opinion both in the literature and in our own series of cases. The colour index is by no means infallible and cannot be relied upon unless associated with megalocytosis, a feature which in mild and doubtful cases requires accurate determination by Price-Jones' method.[43] Campbell and Conybeare state that a colour index of 0·7 to 1·0 is as common in pernicious anæmia as is a larger index; but that, despite the low index, megalocytosis is constant, the average diameter of the red cells being somewhere in the region of 8 μ or more, instead of the normal 7 to 7·5 μ. *Tables VIII* and *IX* show an arbitrary division of our cases into those with a colour index of 1·0 or more, and those with an index of less than 1·0. Approximately this division indicates those corresponding most nearly with true pernicious anæmia, and those with features more characteristic of secondary anæmia. The red cells have been measured in the five cases with a high colour index, and in five of the cases with a low colour index where the film showed anisocytosis.

Table VIII.—Colour Index: 1 or More. Pernicious Type.

Case No.	Sex	Degree of Anæmia	Hæmoglobin	Red Cells	Colour Index	Average Size of 500 Red Cells	Percentage of HCl in Stomach	Film
			Per cent	Millions				
5	M	Mild	88	4·16	1·1	7·1μ	Nil	Anisocytosis
12	M	,,	78	4·05	1·0	7·35μ	28	Normal
38	M	,,	85	4·27	1·0	7·05μ	8	,,
18	M	Marked	85	3·4	1·3	7·2μ	Nil	Anisocytosis
33	M	,,	80	3·58	1·1	7·1μ	Nil	,,

Table IX.—Colour Index: Less than 1. Secondary Type.

Case No.	Sex	Degree of Anæmia	Hæmoglobin	Red Cells	Colour Index	Average Size of 500 Red Cells	Percentage of HCl in Stomach	Film
			Per cent	Millions				
8	M	Marked	60	4·61	0·7	7·05μ	—	Anisocytosis
9	M	,,	75	3·9	0·9	6·95μ	10	Normal
20	M	,,	40	4·2	0·5	—	Nil	Poikilocytosis
37	M	,,	45	5·7	0·4	—	,,	,,
44	M	,,	62	5·45	0·6	6·95μ	—	Anisocytosis
4	F	,,	60	4·82	0·5	—	—	Normal
13	F	,,	36	5·2	0·3	—	—	Poikilocytosis +
22	F	,,	62	5·23	0·5	—	Nil	Normal
24	F	,	55	4·11	0·6	6·9μ	,,	Anisocytosis
36	F	,,	25	3·89	0·3	—	— (Malignant recurrence)	Poikilocytosis ++
40	F	,,	47	3·7	0·6	6·9μ	Nil	Poikilocytosis
51	F	,,	38	3·78	0·5	—	,,	,,
52	F	,,	36	3·88	0·45	—	,,	Poikilocytosis +

As far as can be seen from these tables there is no evidence of pernicious anæmia, but reference to the above account will show that 7 males and 8 females were suffering from a severe anæmia, and that 8 males had a mild degree of anæmia; thus 44 per cent of the whole series possessed some degree of anæmia. Taken as a whole the average red cell count was 4·97 million, and the average percentage of hæmoglobin was 70·5. These figures, however, give a false impression with regard to the condition of the individual patients. It must be remarked that even those cases with severe anæmia were carrying on their normal occupations, and a few only complained of fatigue and breathlessness on exertion; in no case was treatment sought.

Biochemical.—The chemical analysis of blood did not reveal any characteristic change in any of the constituents.

URINE TEST (*Chart IV*).

The urine was examined for abnormal constituents in each case. A trace of sugar was found in 7 cases—6 male and 1 female. In 2 of these the blood-sugar was raised, and acetone bodies were present in 5 of the specimens of urine. Although at first sight it might be thought that these findings pointed to a pancreatic lesion, examination of the fæces did not support the contention that a chronic pancreatitis might be present. In only 8 of the cases was there any evidence of renal disease, these specimens containing pus cells, albumin, etc. One of them only, however, showed any nitrogen retention in the blood. Indicanuria was present in 21 cases. The relation between the specific gravity of the urine and the emptying time of the stomach has already been referred to.

EXAMINATION OF THE FÆCES (*Chart V*).

The relation of the presence of hydrochloric acid in the stomach to the amount of fermentation in the large bowel was studied. For the most part the bowels of the patient moved normally, with a tendency to a loose motion. A few were constipated, but this was the exception to the general rule. The fat content of the fæces throughout the whole series showed a tendency to be above normal; there were undigested muscle fibres present in a few cases, and undigested connective tissue in about half the cases examined. The macroscopical examination of the fæces showed that most were semi-formed, all contained bile, blood usually being absent. Bacteriological examination showed that whilst the total organisms were increased, no particular group was increased constantly throughout, anaerobes, streptococci, and *Bacillus coli* being in excess in different cases. There was, however, no evidence of the predominance of the *Bacillus welchii*. An attempt to correlate the fæcal findings with the presence or absence of hydrochloric acid in the stomach content showed that no particular difference occurred in achlorhydria, and that the presence of muscle striæ and increased fats was probably due to the increased rate of flow along the alimentary tract. Connective tissue was often present in those cases in which there was achlorhydria and rapid emptying of the stomach. The only explanation of the presence of an excess of organisms in the fæces is the rapid emptying time of the stomach associated with a very

URINE											
CASE	SUGAR	ROTHERA TEST	SPECIFIC GRAVITY	REACTION	PROTEIN	TOTAL N_2 grms %	NH_4 COEF. %	UREA IN grms %	CHLORIDES IN grms	INDICAN BODIES	DEPOSIT
1	—	−+	1004	ACID	—	·29	4	·7	·18	+	PUS
2	—	—	1008	ACID	—		4	·69	·57	—	NIL
3	—	—	1012	ACID	+	·61	4	·67	1·2	−+	PUS
4	—	—	1012	ACID	—	·90	4	1·65	·92	−+	NIL
5	+	+	1018	ACID	—	·40	6	·6	·61	++	DEBRIS
6	—	—	1015	NEUT.	—	·70	3	1·3	1·0	+	NIL
7	—	—	1012	ACID	—	·67	6	1·06	·95	—	NIL
8	—	—	1006	ACID	—	·51	3	·75		—	NIL
9	—	—	1012	ACID	+	·48	4·5	·9	·72	−+	PUS
10											
11	·1%	++	1018	ACID	+	·96	4	1·2	·57	—	PUS
12	—	—	1012	ACID	—	1·6	3	1·3	·66	++	NIL
13	—	+	1012	ACID	—	·90	6	1·45	·64	++	NIL
14	·2%	+	1020	ACID	—		4·5	1·1	·56	—	NIL
15	—	−+	1008	ACID	+		6	·84	·54	−+	NIL
16	—	+	1018	ACID	—		2	1·18	·54	—	NIL
17	—	—	1016	ACID	—	·56	4	1·05		—	NIL
18	—	−+	1006	ACID	—		5	·45	·39	—	NIL
19	—	—	1014	ACID	—	·52	4	·75	·67	+	NIL
20	—	—	1005	ACID	—	·28	5	·38	·47	—	NIL
21	—	—	1018	ACID	—	1·2	3	1·5	·68	+	NIL
22	—	−+	1011	ALK.	+	2·8		·47	·99	—	PUS
23	—	—	1008	ACID	+		4	1·1	·54	—	NIL
24	+	+	1018	ACID	—	·85	8	1·15	·46	+	NIL
25	—	—	1012	NEUT	—	·43	4	·68		—	NIL
26	—	−+	1005	ACID	—	·33	3	·38	·59	+	NIL
27	—	—	1008	ACID	—		5	·68	·43	—	NIL
28	—	—	1020	ACID	—		3·8	·85	·54	—	PUS
29	—	—	1015	ACID	—	·70	4	·95	1·1	+	NIL
30	·1	—	1012	ACID	—		4	·84	·56	+	
31	—	—		ACID	—	·65	4	1·05	1·1	—	NIL
32	—	—	1016	ACID	—		2·5	1·5		—	NIL
33	—	—	1020	ACID	—	1·0	5	1·4	1·1	+	NIL
34	—	—	1018	ACID	+		4	·85	·52	—	PUS
35	—	—		ACID	—	1·3	3	1·8	1·0	+	NIL
36	—	+	1010	ACID	—	·65	4·8	·95	·43	+	DEBRIS
37	+	—	1019	ACID	—	·87	4	1·2	1·3	+	DEBRIS
38	—	−+	1015	ACID	—	·76	3	1·05	·70	++	NIL
39	—	—	1010	ACID	++	·66	4	1·05	·72	—	PUS
40	—	—	1002	ACID	—	·20	3	·3	·31	+	NIL
41	—	—	1004	ACID	—	·24	6	·3	·26	—	NIL
42	—	—	1003	ACID	—	·21		·35	·23	—	NIL
43	—	−+	1008	ACID	+	1·2	4	·76	·50	—	PUS
44	+	+	1020	ACID	+	·82	4	1·45	1·2	+	PUS
45	—	—	1019	ALK.	—	·85		1·25	1·1	++	NIL
46	—	—	1012	ACID	—	·80	3	1·05	1·1	+	NIL
47	—	—	1008	ALK.	—	·30		·4	·22	—	NIL
48	—	—		ALK.	—		3	1·05	·78	—	NIL
49	—	—	1012	ACID	—		8	·65			NIL
50	—	—	1005	ACID	—	·22	7	·38	·31	—	NIL
51	—	+	1010	ACID	—	·55	4	·6	·39	++	DEBRIS
52											

Chart IV.—*Rothera test :* − + = faintly positive. + + = strongly positive.
Indican bodies : − + = trace. + + = large quantity.

FÆCES

CASE	GENERAL APPEARANCE	BILE	BLOOD	MUCUS	FIBRIN	MUSCLE STRIÆ	TOTAL FATS grms %	UNSOAPED FATS grms %	NEUTRAL FATS grms %	FREE FATTY ACID grms %	COMBINED FATTY ACID grms %	ANÆROBES	STREPTO-COCCI	B. COLI
1	SEMI-SOLID	+	—	—	—	—	19·8	16·8	1·1	15·7	3·0			
2	NORMAL	+	—	—	—	—	26·3	17	4·9	9·3	12·1			
3														
4														
5	SEMI-FORMED	+	TRACE	+	+	—	23·6	10·8	1·9	8·9	12·8	+++	+	++
6	NORMAL	+	—	—	—	—	32	14·8	2·3	12·5	17·5	+	++	+++
7	SEMI-FORMED	+	—	—	—	—	17·5					+	++	+++
8												+	+	++++
9														
10	SEMI-FORMED	+	—	+	+	—	NORMAL					+	+++	++
11														
12	SEMI-FORMED	+	—	—	—	—	39	31·3	25·5	7·8	7·7	+++	++	+
13	FORMED	+	—	—	—	—	16	8·6	1·5	7·1	7·4	+	++	+++
14	FORMED	+	—	—	+	—	28·6	17·2	3·7	13·5	11·4			
15														
16	NORMAL	+	—	—	+	—	30·4	21·2	6·5	13·7	9·2	++++	+	+
17	FLUID	+	—	+	+	—	32					+	+	++++
18														
19	NORMAL	+	—	—	—	—	28·2					++	++++	+
20	SEMI-FORMED	+	—	—	+	+	53·2	38·4	2·5	35·9	17·3	+	+	++++
21														
22														
23	NORMAL	+	—	—	+	—	21	13·2	3·3	9·9	7·8	++++	+	+
24	SEMI-FORMED	+	—	+	—	—	66	56·4	44·7	11·7	9·6	+	+	++++
25	SEMI-FORMED	+	—	—	+	—	31·3	8·8	·2	8·6	22·5	++++	+	+
26	FORMED	+	—	—	—	—	33·9	17·0			16·7			
27	FORMED	+	—	—	—	—	18	4·1	·1	4	14			
28														
29	FORMED	+	—	—	+	FEW	22·4	12·2	2·5	9·7	10·2	+++	++	+
30	SEMI-SOLID	+	—	—	—	—	26·5	10·3	1·1	9·2	16·2			
31	SEMI-FORMED	+	+	—	+	—	28·5					++	+++	+
32	NOT-FORMED	+	+	—	++	—	NORMAL					+	+++	++
33	FORMED	+	—	—	+	—	24·9	7·3	·7	7·1	17·1			
34														
35	SEMI-FORMED	+	—	—	+	—	29·5	9·7	2·1	7·6	19·8	++++	+	+
36														
37	SEMI-FORMED	+	—	—	+	—	32·4	16·3	2·3	16·1	14	++	+++	+
38	FORMED	+	—	—	+	—	++					+++	++	+
39	SEMI-FORMED	+	—	+	+	—	17·6	12·4	5·6	6·8	5·2	++	+	+++
40														
41	FLUID	+	—	+	—	—	34·9					++	+++	+
42	SEMI-FORMED	+	+	—	—	—	21·6	12·8	3·1	9·7	8·8	+++	++	+
43	NORMAL	+	—	—	—	—	15·8	6·4	1·6	4·8	9·4	++	++	++
44	SEMI-FORMED	+	—	—	+	—	27·6	20·1	7·1	13·	7·5	+++	+	++
45	SEMI-FORMED	+	—	—	+	—	35					+	++	+++
46	FORMED	+	—	—	+	—	27·2					+++	++	+
47	SEMI-FORMED	+	—	—	++	—	31·7					++	+	+++
48	NORMAL	+	—	—	+	—						+++	+	++
49														
50	SEMI-FORMED	+	—	—	—	—	40·3	16·6	2·8	13·8	23·7	++	+	+++
51	FORMED	+	—	—	—	—	35·2	9·2	1·2	8	26	+++	++	+
52												++	++	++

Chart V.— — = normal. + = excess.

rapid neutralization of the gastric contents, and a limited exposure of the food to the hydrochloric acid. That there was excessive putrefaction in the colon in some cases was shown by the presence of indican bodies in the urine.

COMMENTARY.

At the commencement of these investigations our knowledge of the results of gastrectomy was based upon impression and not on fact. It is now possible to examine critically the information obtained by three groups of independent workers from the cases in this series. In this commentary we intend to restrict ourselves to a discussion of the more important findings. Our results confirm the statements of the older investigators, that the stomach could be removed from animals and from human beings without the individual being afterwards seriously incapacitated. Post-operative efficiency of the patient when compared with that before operation has been shown to be overwhelmingly increased in the vast majority of cases, thereby demonstrating that the patients could not be suffering from any severe alimentary or metabolic disturbance. Confirmation of this view would also seem to be forthcoming by reason of the gain in weight shown by nearly every case after operation.

It is interesting at this juncture to consider the accepted views as to the functions of the stomach. The standard text-books of physiology state that the rôle of the stomach lies in the conversion of insoluble foodstuffs into soluble products of digestion. Thus proteins are converted first to meta-proteins, and are then broken down to proteoses; starch is hydrolysed to soluble products, while fatty tissue undergoes liquefaction through the digestion of the protein envelopes. All these changes take place in a reservoir—the stomach—effectively separated from the narrower duodenum by the special mechanism of the pylorus, which permits the passage of food only when suitably altered in quality and in such quantities as will not overcrowd this narrow tube into which pours at intervals the powerful digestive pancreatic juice. The operation of gastrectomy robs the patient of the whole of this mechanism, and since he can exist quite satisfactorily without it, one might reasonably conclude that the digestive function of the stomach is in the nature of refinement.

Apart from its property of activating the pepsin, the hydrochloric acid of the gastric juice is also usually regarded as possessing very important antiseptic functions. We find little evidence that the patients under consideration suffer from serious intestinal putrefaction, except for an increase in the fæcal bacteria, a fact elicited solely by laboratory examination. Whilst it must be admitted that 40 per cent had indicanuria, the main biochemical difference noted between these patients and normal subjects, apart from the test-meal findings, was the lack of control of water absorption, as demonstrated by the sudden drop in the specific gravity of the urine following the test-meal.

Chemical analysis of the blood showed that there was no striking abnormality other than a slight rise in the uric acid and cholesterol contents. There is no obvious reason why this increase should occur, and more work is being done on this point. It should be noted that the physiological conclusions drawn from these cases cannot be designated as final, in that they are

drawn from patients in whom a small portion of stomach still remains, the whole of their secreting gastric mucosa not having been removed.

The remaining facts to which we particularly wish to draw attention are two in number: first, the high proportion of patients suffering from secondary anæmia; and secondly, the discovery that 20 per cent of the total number investigated are secreting an acid juice. It is more opportune to deal with the anæmia first.

Lake (loc. cit.) states that neither pernicious nor secondary anæmia has occurred in his series. We agree with him only in the fact that no case of pernicious anæmia has been found in our series; but the number of our cases in whom secondary anæmia was discovered approaches very closely to the figures given by Morley (loc. cit.), who in November, 1928, reported that 50 per cent of his gastrectomized patients were suffering from a secondary anæmia. When our cases were analysed as to a possible source of the anæmia, it was found that, whereas a certain number showed clinical evidence of anæmia, only a few of these were by laboratory methods found to be suffering from secondary anæmia; on the other hand, many who were not clinically anæmic were discovered by laboratory methods to be suffering from a marked anæmia. The difficulty was increased by the fact that all these patients except two, one of whom is 50 per cent and the other 100 per cent efficient, were at full work and had sought no advice for any ailment. On reference to our clinical records it was found that one or two of these complained of tiring easily, especially towards the end of the day; but they appeared to recover rapidly with food and a short rest. Our difficulty was further increased by the fact that two of the four patients who were 50 per cent efficient showed no evidence of anæmia, and the position was rendered still more perplexing when we discovered that one patient, a female who had had a wide sleeve resection of her stomach for a gastrojejunal ulcer, and two years later a resection of the right half of the colon for diverticulitis, has now a normal blood-count. At both of her operations she was profoundly anæmic, and on each occasion was transfused with blood. In view of this isolated case, the averred relation of achlorhydria to anæmia is rendered still more confusing by reason of the fact that three of our patients suffering from anæmia had free hydrochloric acid in the stomach. It is unfortunate that we have no record of a pre-operative blood-count in the majority of our cases. At present we are unable to give any reason for the secondary anæmia, and more work is being done on this point.

With regard to post-operative acidity, previous surgical writers have maintained that gastrectomy produces more certain results in the treatment of ulcer than does gastro-enterostomy, for two reasons: first, the patient is rendered achlorhydric; and secondly, he has been divorced from the ulcer-bearing area of his stomach. Some writers maintain that the beneficent effect of the operation is solely due to the achlorhydria; others lay great stress upon the importance of the removal of the lesser curvature, and the removal of the pylorus has also been advocated. We feel that it is quite definite that the first of these theories must be reconsidered, since 20 per cent of our cases show evidence of free hydrochloric acid. Partial gastrectomy does not guarantee that the patient on whom it is performed will be rendered acid-free.

It may be mentioned that, however careful a technique is adopted, errors may sometimes arise in the somewhat gross technique of the fractional test-meal. Yet even with this method, which is the best known at the present time, it is possible to show that hydrochloric acid is still present in a large number of the patients. It is probable that, if a better technique were known, we should find that these patients were secreting more acid than we have shown.

The question now arises: How does gastrectomy produce its good results? That it does not produce achlorhydria is amply shown by us. Perman (loc. cit.) has recently obtained similar results to ours, for in a study of 9 gastrectomized patients, he found that hydrochloric acid was present in demonstrable quantities in 3 cases of gastric resection by the Billroth I method, in 3 cases out of 4 by the Billroth II method, and a trace in 2 cases of almost complete gastrectomy. It is interesting to observe at this juncture that, as already mentioned, Wroblewski in 1897 found hydrochloric acid present in the stomach contents of a patient operated upon by Schlatter. These results are not surprising, since recently Miyagawa[44] has verified the results of many other workers in showing that oxyntic cells are distributed over almost the whole of the stomach surface. He found that they were most numerous in the fundus glands, especially along the lesser curvature and the prepyloric region; they are also found in lesser numbers in the pyloric and cardiac glands. The view that excision of the pylorus is responsible for true achlorhydria is contrary to the findings of Klemensiewicz and most modern workers, who have shown that the pylorus secretes an alkaline fluid.

Unless the whole of the stomach is removed and the jejunum anastomosed to the œsophagus, the surgeon is not excising the whole of the potential acid-forming mucosa. On the other hand, in the partial removal of the stomach a certain proportion of the acid-producing area is removed, and the amount of acid produced in each particular patient will be in a definite ratio to the amount of stomach excised. Such a stomach is opening directly into the jejunum, which is secreting a highly alkaline juice, the stoma itself and the stomach being open to regurgitation of the jejunal contents without the interference of pyloric control, and obeying an unknown but newly developed mechanism which depends upon gravity and the opposing forces of gastric and jejunal peristalsis. We have therefore these factors: a lower gastric acidity than normal, a less mobile stoma, and a potential source for very rapid neutralization.

The efficacy of the Pólya modification of the Billroth II operation does not appear to depend upon the removal of the acid-secreting mucosa of the stomach alone, but also upon the efficient neutralization of any acid that the remaining portion of the stomach may secrete, because in partial gastrectomy by the en-Y method, recurrent ulceration occurs fairly frequently, and for this reason this particular technique was abandoned. In these unsuccessful cases the cause of recurrent ulceration appears to be that the blind loop of the jejunum has to depend for its protection upon only the alkaline secretion of its own mucosa, for the ascent of the alkaline duodenal and jejunal contents is merely fortuitous, and leaves the upper limbs of the Y undefended against the acid of the stomach. (*Figs.* 597, 598.)

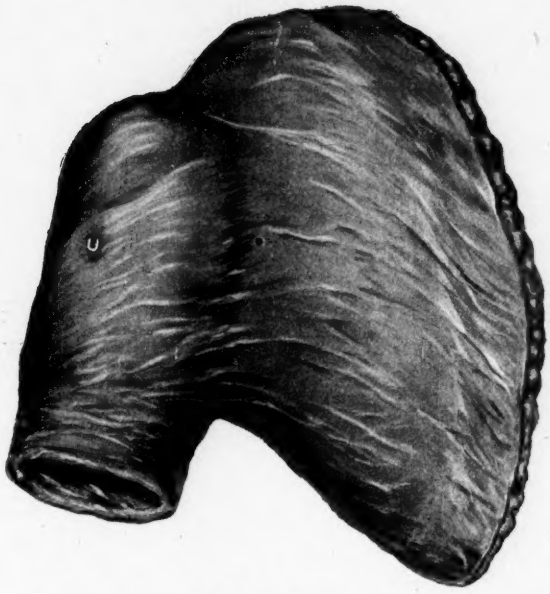

FIG. 597.—The stomach and limb of the Y, showing position of ulcer (U).

FIG. 598.—The ulcer as viewed through the gastrojejunal junction.

We also feel sure that if an entero-anastomosis is performed between the afferent and efferent loops of the jejunum after a partial gastrectomy by the Balfour-Pólya ante-colic method, the condition of the portion of the intestine between the two stomata will be as precarious as that of the blind loop of the en-Y anastomosis.

A moment's reflection upon the means by which the skilled physician effects and maintains the cure of a patient suffering from a benign ulcer of the stomach or duodenum suffices to make it clear that he achieves this success by inhibiting the secretion of the acid juice of the stomach and its motility by means of atropine and by making the gastric contents as persistently alkaline as the 'threshold of alkalosis' will allow. It appears, therefore, that both the physician and the surgeon are attempting to cure their patients by methods of treatment fundamentally similar, though they essay to attain their objective by following different routes. If the acid secretion of the stomach is the most important factor which determines the success of both surgical and medical treatment, the surgeon who performs an operation which does not remove an adequate portion of the acid-secreting mucosa must be prepared to accept a certain percentage of failures. If, however, he does perform such an operation for ulcers which have failed to respond to medical treatment, he must also be prepared to face a relatively high immediate mortality, but he should remember that the mortality of such patients without his aid would be in the neighbourhood of 100 per cent.

The realization of these reasonings furnishes the key to successful therapy; a wise and close co-operation between physician, surgeon, and laboratory worker will lead to timely operative interference and to the performance of the appropriate operation should surgery be required to deal with patients whom medicine has failed to cure.

SUMMARY.

1. In 52 cases of gastrectomy no serious alimentary or metabolic upset was found.

2. In 44 per cent of the series a definite anæmia was present, but this was discovered through laboratory examination and was not associated with any symptoms. The anæmia does not resemble the pernicious type, and no evidence of the occurrence of pernicious anæmia can be found in any of the cases.

3. Hydrochloric acid was found in 20 per cent of the whole series.

4. Fibrin was present in 50 per cent of the fæces, and there was a general tendency to an increase in the fæcal fat. Some increase of the intestinal flora was found, but without increase in any specific type of organism.

5. Cases with a rapid emptying time of the stomach showed a sudden drop in the specific gravity of the urine following the test-meal. The importance of the pyloric control of water absorption is hereby demonstrated.

6. An increase in the blood-cholesterol and uric acid were the only abnormalities found in the chemical examination of the blood.

7. The bearing of these results on the theoretical considerations of gastrectomy are discussed.

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SPECIAL ARTICLES ON SURGICAL TECHNIQUE.

THE SURGICAL TREATMENT OF RECURRENT CHOLELITHIASIS.

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The recurrence of gall-stones either in the gall-bladder or in the ducts must in every case be regarded as a surgical failure. When it is possible to carry out the correct procedure at the primary operation, recurrence is unknown. The commonest cause of failure is the performance of cholecystostomy instead of cholecystectomy, for it seems certain in the light of our present knowledge that all calculi, with the possible exception of those found in patients with acholuric jaundice, are due to an infection which is most commonly situated in the thickness of the gall-bladder wall. Hence it would be expected that if the gall-bladder is drained when it should be removed, or if it has to be left owing to the severity of the patient's condition, recurrence within the viscus would be relatively common. Such recurrences have been variously estimated as between 5 and 15 per cent. In my own series there have been 441 operations for gall-stones, of which 51 consisted of simple removal of the stones and drainage of the gall-bladder. Of the 26 cases of recurrent calculi in the same series, there were 7 in which I had personally performed the first operation. Of these 7, 3 had had a cholecystostomy only: that is, of 51 cholecystostomies nearly 6 per cent had recurrence within the gall-bladder. Of the 19 cases performed elsewhere, 17 had only had a simple cholecystostomy, and all of these had stones present in their gall-bladders. It is also of interest to note that since 1919, when cholecystectomy became my operation of choice, there have been no recurrences. In the performance of cholecystostomy the use of a purse-string suture of silk to fix the tube will be an added cause of calculi formation. In my own series there was one case where stones had formed around a silk suture inserted by another surgeon fifteen years previously (*Fig.* 599). Several similar cases have been reported by others.

FIG. 599.—Recurrent calculi formed in the gall-bladder around a silk suture.

Undoubtedly the majority of apparent recurrences are due to stones being overlooked at the time of the first operation, and therefore are not true recurrences. This is so even in the gall-bladder, where stones may easily be overlooked as they lie in one of the crypts or in Hartmann's pouch. In one of my cases where cholecystostomy was performed for gangrene of the gall-bladder, four stones escaped from a sinus five weeks later, although at the time of operation it was felt certain that none were overlooked. Such stones are certain to be removed by cholecystectomy.

When situated within the common duct they are even more prone to be overlooked. Under such circumstances they will probably cause symptoms shortly after the first operation; they will generally be faceted and will contain cholesterin. Stones of this nature are never formed in the common duct, but are passed there from the gall-bladder. Since a simple cholecystostomy does not allow of adequate exploration of the common duct, apparent recurrence in the duct is more common after this operation. Apparent or real recurrence of calculi is common with the anatomical anomaly in which the cystic duct is very long and joins the common duct at the upper level of or even behind the duodenum. If a simple cholecystectomy is performed without exploration of the ducts, a long piece of the cystic duct may be left in which stones re-form or are overlooked. Even if the duct is slit up and care is not exercised, it may be mistaken for the common duct, and a stone in the latter duct be overlooked (*Fig.* 600). The ideal operation, therefore, to lessen the possibility of this complication, is removal of the gall-bladder, exploration of the common duct from within, and dilatation of the papilla. Even when the duct is opened, small calculi may pass up into the dilated hepatic ducts during the exploration, and so be overlooked. Of the 4 cases of recurrence in my own series of 390 cholecystectomies (1 per cent), 3 had calculi in the

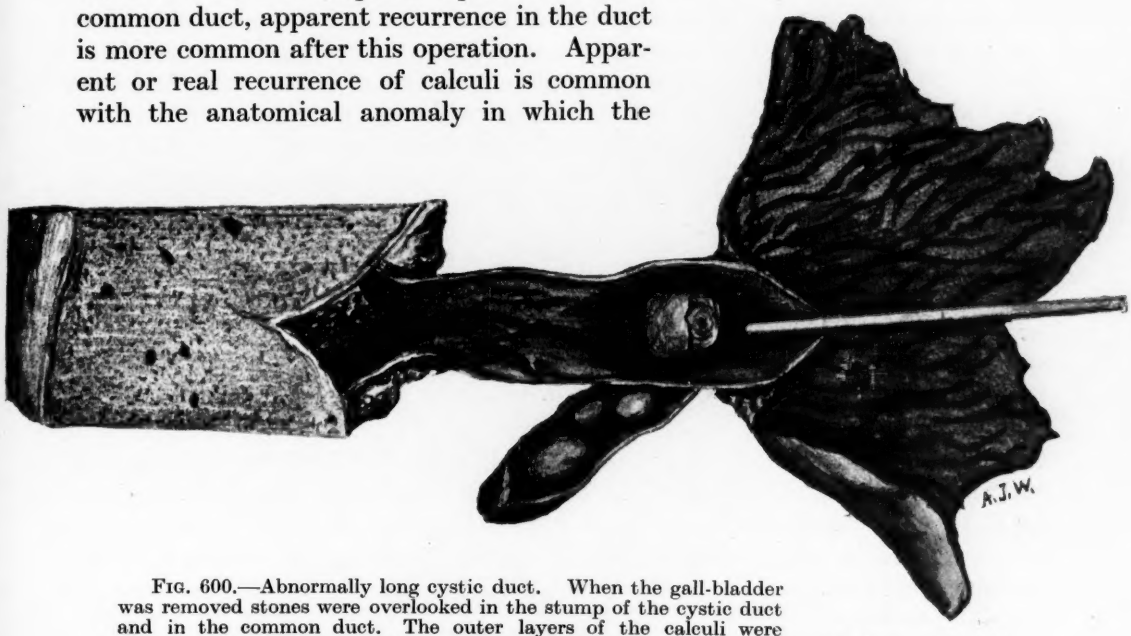

FIG. 600.—Abnormally long cystic duct. When the gall-bladder was removed stones were overlooked in the stump of the cystic duct and in the common duct. The outer layers of the calculi were formed of pure pigment calcium, and were formed in the ducts: the centres were laminated and contained cholesterin, showing that they were formed in the gall-bladder, and had passed down into the ducts. (*From a specimen in the London Hospital Museum.*)

common duct at the first operation, but had little or no period of freedom afterwards, while in the fourth the common duct had not been explored. If the opening of the duct is dilated from within, small stones that have been overlooked will be passed and will not lead to apparent recurrence. In the 200 cases upon which cholecystectomy has been performed since 1919, when this method of dilatation was first used as a routine, there has been no case of recurrence in the common duct. The severity of the pathological lesion, and the condition of the patient, may, however, prevent this ideal operation being performed, and the surgeon may have to be content with simple drainage, consoling himself with the thought that a live patient with a possibility of recurrence is better than a fatal result of a complete operation.

The other variety of recurrent common-duct stones may appear after a long interval. It occurs with infection and dilatation of the duct, and consists of a relatively soft mass formed of pure pigment calcium. It is probably formed *in situ* and is due to chronic infection of the duct, and therefore contains no cholesterin, which appears to be deposited only in the gall-bladder itself. Its presence would probably have been prevented if the duct had been adequately drained or the ampulla efficiently dilated.

If the calculus is formed of pure pigment calcium, whether in the gall-bladder or the common duct, it is always well to remember that it may be due to acholuric jaundice. Such calculi are almost certain to re-form in the gall-bladder if it is drained, or in the common duct after cholecystectomy. An appreciation of this fact will lead to the necessary splenectomy and prevent recurrence. One of my own series was of this nature, but many others have been recorded.

When for any of the above reasons calculi have re-formed, surgical treatment is sure to be required, and careful preparation must be made, as the operation may be very tedious and prolonged. Preliminary calcium medication will generally be necessary, and, if the jaundice is of the grey-green type, tests of hepatic efficiency may also be useful, for in such cases the duct may be filled with the so-called white bile, indicating that the liver function is in abeyance and that the patient will have but little reserve to stand a long and tedious operation.

GENERAL OPERATIVE TECHNIQUE.

My own preference is for general anæsthesia with open ether or warmed ether vapour. The lower thorax is arched forward with a small sandbag, or the raised cross-bar of the table, placed at the level of the lower dorsal vertebræ.

A vertical incision 1 in. to the right of the middle line and extending from the xiphisternum to the umbilicus gives the best access. Owing to the old incision, the sheath of the rectus will have to be dissected and cannot be stripped from the muscle. When the muscle has been retracted, it is best to incise the posterior sheath high up. There are certain to be many adhesions, but these are less likely to be present over the liver, or, if present, less harm will arise from making a small nick into the liver substance than into a loop of adherent gut. When the peritoneal cavity is entered, a finger is inserted and swept down to allow the rest of the incision to be completed. As soon as this is done,

all adhesions must be carefully dissected. There is no abdominal operation in which it is more necessary to follow the rule that pathological conditions are to be neglected until the normal anatomy is restored.

If the gall-bladder is present, it is carefully freed from the abdominal wall, colon, omentum, and duodenum, to one or more of which it will be found to be attached. An automatic retractor is now inserted and the rest of

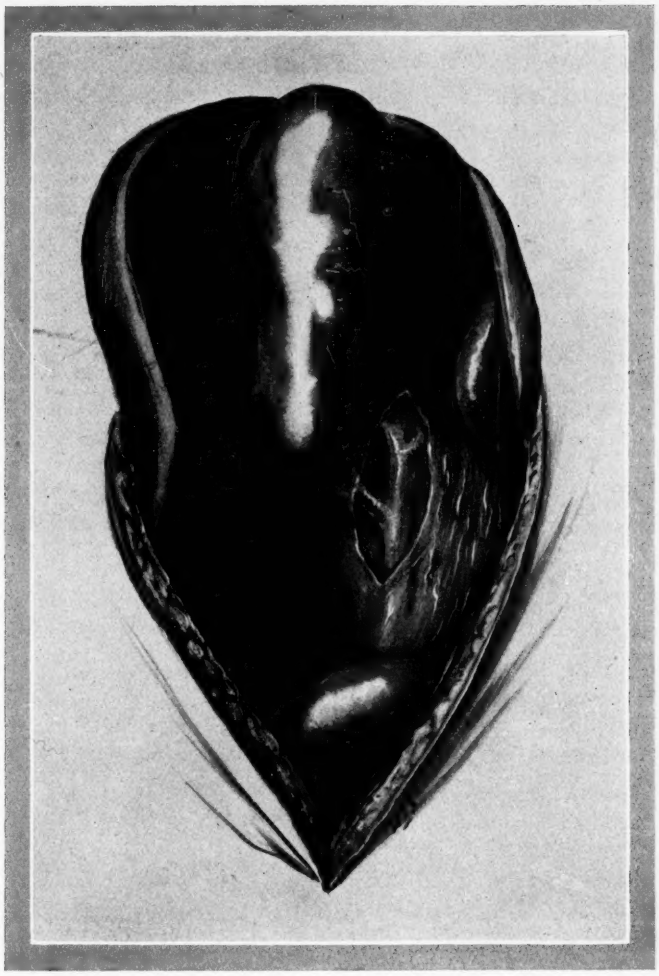

FIG. 601.—Incision into the lesser omentum and dissection of the cystic, common hepatic, and common bile-ducts.

the viscera packed off with three pads: one to the right, one to the left, and one below, the latter being held in position by the assistant's left hand, which thereby keeps the colon and duodenum out of the field and exerts moderate tension upon the lesser omentum and common duct.

The gall-bladder is gently pulled upwards, and the peritoneum around Hartmann's pouch and the cystic duct dissected off. The dissection is

continued until there is a free exposure of the cystic duct, the common hepatic duct, and the common bile-duct (*Fig.* 601). No structure whatever must be divided until all three are clearly displayed. The cystic duct, being isolated, is divided between two clamps, the lower of which is placed close to the common duct. The cystic artery is then ligatured and divided. A fourth pad is now placed in the right renal pouch in the foramen of Winslow. The clamp is

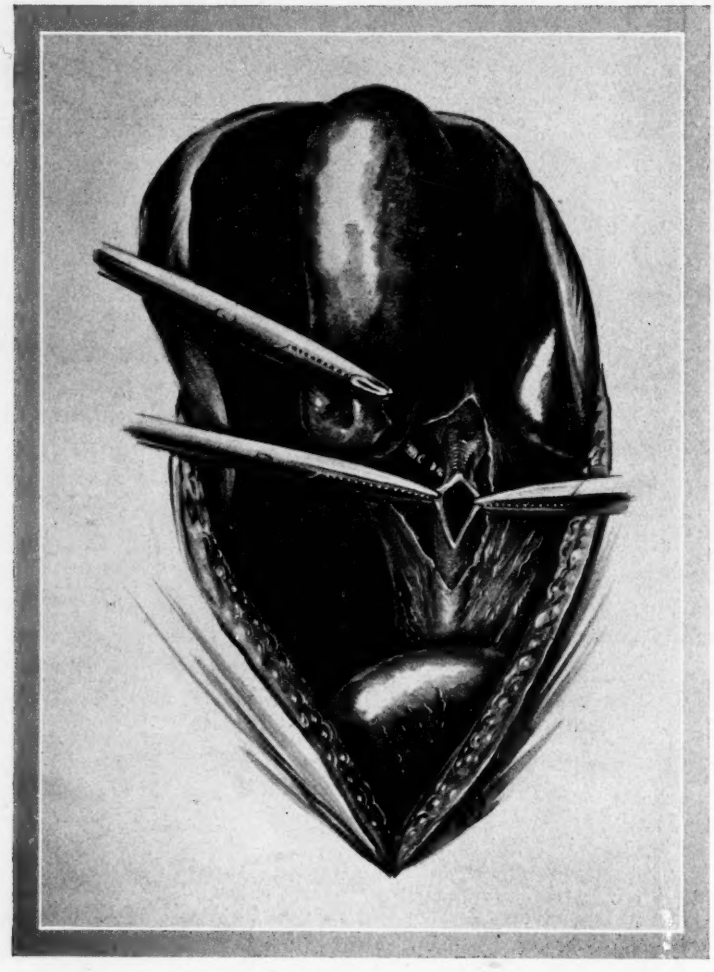

FIG. 602.—Division of cystic duct and incision through its stump into the common bile-duct.

slipped off the stump of the cystic duct, and the wall of the latter incised downwards so that a free opening is made into the common duct (*Fig.* 602). If the gall-bladder has already been removed, considerably greater difficulty may be experienced. The duodenum or omentum should be freed from the under-surface of the liver, the dissection being continued downwards until a finger can be inserted into the foramen of Winslow. If the common duct is dilated, it may be clearly visible, but if contracted, very great difficulty may

be experienced in finding it. The dissection must then be very slow and cautious. If there is any doubt as to the nature of an exposed structure, a small hypodermic needle may be inserted into it, and, if bile is drawn off, the identity of the structure will be certain. By the use of this method a great deal of time may occasionally be saved. When the duct is identified, a longitudinal incision should be made into it at approximately the site of the cystic duct.

Treatment of the Common Duct.—The lateral edges of the incision are grasped with small forceps so as to fix the duct. A delicate pair of curved

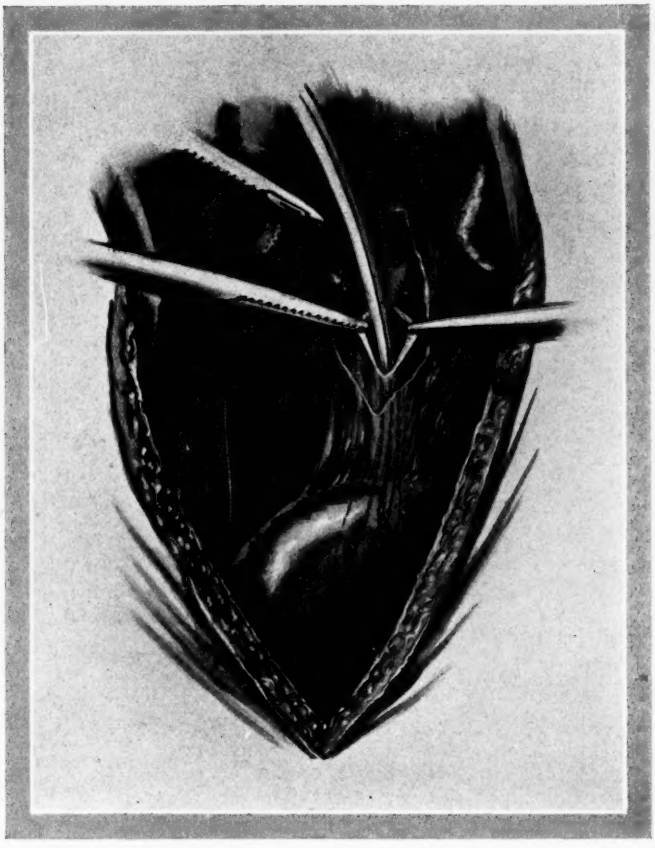

FIG. 603.—Removal of calculi from common bile-duct with forceps.

gall-stone forceps is inserted into the duct and passed downwards. By gently opening the blades, any calculi can be seized and drawn upwards (*Fig.* 603). This manœuvre is repeated until all stones are removed. A certainty that the duct is clear can only be obtained when the forceps enter into the duodenum through the ampulla. It has on several occasions happened that the forceps have failed to enter the duodenum, and although no stone could be felt from without, one has ultimately been removed from the ampulla in which it was impacted, and the surgeon should therefore only be satisfied

when the forceps are felt to slip past the papilla and to enter the duodenum. As soon as this is accomplished, the blades are gently opened several times so as to dilate the papilla to its fullest extent. Occasionally a stone in this latter situation will be so firmly fixed that it may be impossible to draw it upwards with the forceps, and it will then be necessary to incise the second portion of the duodenum, and perhaps even to slit up the papilla of Santorini.

FIG. 604.—Suture of lesser omentum and bed of gall-bladder.

This, however, will very rarely be the case if patience is exercised in the use of the forceps from above. Should it be necessary, the second part of the duodenum is drawn upward, is well packed off, and a small vertical incision made in it opposite the opening of the papilla. If the papilla is not immediately apparent, it can generally be exposed by exercising gentle pressure on the forceps in the common duct, and so pressing the ampulla and the

papilla forwards. The opening of the duct may be carefully enlarged with a small scalpel or tenotomy knife, and, by gentle manipulations from above and below, the stone can be dislodged and removed. The duodenum is then closed in the usual way by two layers of catgut.

When it is certain that the lower portion of the duct is free, the curved forceps should be turned round and made to enter the two hepatic ducts. Several stones may have escaped upwards, but with care can usually be extracted, and the ducts be left quite clear. If the ducts are very dilated, there is always the possibility that stones have passed up into the dilated intra-hepatic portions, and so been overlooked, but with care this rarely happens.

Drainage of the Ducts.—The chief indication for drainage of the common duct is the presence of infection within it. It was therefore my custom always to insert a tube into the lumen of the common duct if it showed the presence of: (1) Purulent bile; (2) Soft putty-like masses of calcium pigment; (3) Recurrent calculi; (4) Considerable dilatation. With the latter two conditions, however, the infection is relatively mild, or may indeed be absent, and therefore it has been my custom, since the introduction of the method of dilating the ampulla, to abandon the use of drainage of the duct, provided that the dilatation below was satisfactorily accomplished. In the first two conditions a small tube the size of a No. 12 catheter is inserted into the opening of the common bile-duct, is fixed in position by a fine suture of plain catgut, and the rest of the opening of the duct sutured around the tube with lightly-chromicized gut. In the two latter conditions the opening in the duct is carefully sutured with intestinal catgut. A drainage tube is now inserted down to the foramen of Winslow. If the gall-bladder is present, it is gently dissected from the liver bed and removed entirely, the raw area on the under-surface of the liver being carefully sutured with catgut (*Fig.* 604). The pads are now removed and the abdominal wound is closed in layers.

AFTER-PROGRESS.

The after-progress in these cases is usually satisfactory. The patient is returned to bed, given $\frac{1}{4}$ gr. morphia and $\frac{1}{100}$ gr. atropine hypodermically as soon as she begins to recover consciousness. The presence of bile in the post-anæsthetic vomit is often a useful indication that the duct is clear and bile flowing into the duodenum. Sips of fluid are given by the mouth as soon as necessary, and if the patient is at all collapsed, or if the bile in the common duct has been colourless, water is also given per rectum, half a pint being administered every three or four hours. There is a curious belief, probably based on intravenous injections, that it is necessary to give saline per rectum. This is, of course, quite unnecessary, plain or distilled water being more easily and rapidly absorbed. As soon as the patient is well round from the anæsthetic, she should be propped up in the sitting posture. On the day after the operation, she can be given weak tea, meat extracts, and diluted milk to drink, and on the second day custards, jellies, and Benger's food may be added. One of the greatest difficulties the surgeon will have to combat, if not treating the case in his usual home or hospital, is the tendency of those

in attendance to give aperients at an early date. Nothing is so likely to induce ileus as the early administration of pituitary extract or calomel and other aperients by mouth. The bowels should be left entirely at rest until the morning of the third day, when an enema should be administered.

The tube passing down to the foramen of Winslow may be shortened on the third day if there is no biliary discharge, and entirely removed on the fourth or fifth day. To-day there is a dangerous superstition against the use of small drainage tubes. I have never known a tube cause any harm if it is rotated daily, and if there is a small biliary leakage, such as often occurs from the gall-bladder bed, it may prevent serious after-trouble. If entirely removed on the fifth day, it is impossible to determine its site of entry when the stitches are removed on the tenth day. If a tube has been passed into the common duct, this should be kept in position until the tenth day. As a rule, after its removal a little bile continues to escape for two or three days, after which it ceases and the wound rapidly heals.

SHORT NOTES OF RARE OR OBSCURE CASES

FATAL BURN: DEATH DUE TO HÆMORRHAGE INTO THE SUPRARENAL CAPSULE AND TO HÆMORRHAGE FROM A DUODENAL ULCER.

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The rarity of duodenal ulcers and of gross suprarenal hæmorrhage as complications of burns, warrants the publication of the following case history:—

E. H., female, age 3½ years, was admitted to the Hospital for Sick Children, Toronto, on Jan. 18, 1926, six hours after having stumbled backwards into a pail of hot water. A large scald of second and third degree covered the posterior surface of the trunk and thighs from the angles of the scapulæ to the popliteal spaces. Extensive vesication had already occurred. Apart from the local condition, the outstanding feature of the examination of the child was the rapidity and poor quality of the pulse. At the wrist the pulse could scarcely be felt; the tension was low. With a stethoscope over the heart the rate was found to be 186 per minute. The extremities were cold, but the face was not pallid nor was the temperature subnormal (99°). The child was bright and mentally alert, in striking contrast to what might have been expected from the profound circulatory changes. The blood-pressure was not estimated. The rapidity and feebleness of the pulse were attributed to surgical shock, and, in view of their extreme degree, a transfusion of blood was thought advisable: 200 c.c. of whole blood greatly improved the quality of the pulse and reduced its rate to 160.

The burned area, after opening of the blebs, and after cleansing with gasoline to remove an oily dressing, was treated with 5 per cent aqueous solution of tannic acid according to the method of Davidson.[1] Locally the burn progressed in an entirely satisfactory manner. At the end of the first day the dead skin was thoroughly tanned, forming a dry, brown, painless crust. It remained in this condition until the patient died.

The pulse remained rapid, its rate ranging from 150 to 160; its quality was poor, so that frequently it was impalpable at the wrist. On the second day the temperature rose to 102°, and coincident with this the child became drowsy. She vomited stomach contents without blood three times during the second day. At the beginning of the third day she became very much worse. The temperature remained at 102°. The heart-rate rose to 196 (counted by the stethoscope at the apex). The radial pulse could not be felt. She vomited

a large quantity of blood, most of it altered by gastric secretion, but some in the form of clots. About one hour after this, death occurred.

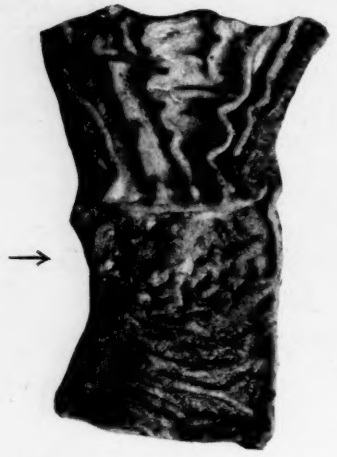

FIG. 605.—Pyloric end of the stomach and first portion of duodenum, opened to show duodenal ulcer just beyond the pyloric ring (marked by arrow).

POST-MORTEM.—A necropsy was performed six hours after death. The essential findings were as follows: All the tissues were extremely dry, as if from dehydration. The mesenteric lymph nodes were moderately enlarged, and varied in colour from greyish red to dark red. The small intestine contained a considerable quantity of altered blood. The mucosa was healthy throughout except in the duodenum. On the posterior surface of this portion of the gastro-intestinal tract, 0·5 cm. from the pylorus, was a shallow ulcer measuring 1 × 0·5 cm. (*Fig.* 605). The base of the ulcer was partially covered with an adherent blood-clot. Upon removal of this clot the base was found to be granular and the margins only slightly raised. The stomach was normal. The left suprarenal was enormously distended with a blood-clot 2·5 cm. in diameter, which had completely disrupted the structure of the gland (*Fig.* 606). The suprarenal, with its contained clot, measured $4\frac{1}{2} \times 2 \times 1$ cm., and was approximately one-third the size of the kidney. Nothing remained of the gland structure save a thin margin of tissue surrounding the blood-clot. Blood from this source had escaped from the suprarenal capsule to form a subcapsular extravasation about the left kidney. This hæmorrhagic layer was thin in front, but posteriorly it averaged 2 mm. in thickness. The right suprarenal looked normal in the gross, but microscopic section revealed hæmorrhages involving the medulla and extending into the cortex close to the capsule. The general structure of this suprarenal had not been altered. The remaining organs were normal.

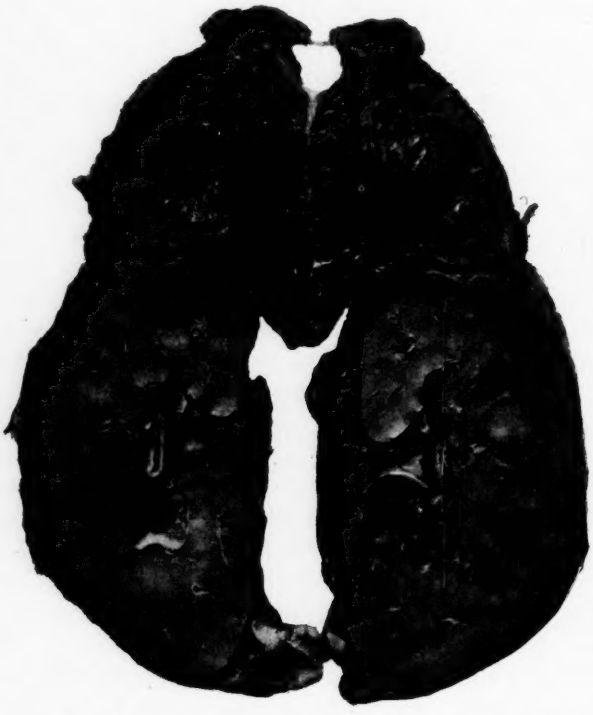

FIG. 606.—Left kidney and suprarenal, split longitudinally to show the enormous hæmorrhage into the substance of the suprarenal.

Microscopical Section.—On microscopic section the duodenal ulcer showed loss of the mucosa and submucosa almost down to the muscular coat. The mucosa surrounding the ulcer was necrotic, as was also the tissue forming its base. The base was partly covered with a coagulum of fibrin, red blood-cells, and polymorphonuclear leucocytes. There were some areas of hæmorrhage in the submucosa. The left suprarenal showed an enormous central hæmorrhage surrounded by a zone of necrotic suprarenal tissue. Some of the veins were thrombosed. The right suprarenal showed scattered areas of hæmorrhage of considerable size throughout both cortex and medulla. In the substance of this suprarenal were three thrombosed veins, one of which was quite large.

Post-mortem Diagnosis. — Cutaneous burn. Solitary duodenal ulcer. Hæmorrhage into both suprarenals.

COMMENTS.

The clinical course of most severe burns, especially those occurring in children, is characterized by a period of toxæmia unlike that found in any other traumatic condition. While knowledge of the causative toxin is still meagre, there has accumulated considerable evidence which points to its origin in the burned area, and its transport to other parts of the body by the blood-stream. Lacking, as yet, accurate knowledge of the mechanism of its production, we may assume the following as a reasonable working hypothesis. The presence of the dead epithelium excites a reaction in the underlying living tissues which ultimately results in the complete separation of the dead from the living cells. This separation is brought about by digestion of dead cells along the line of contact, by means of ferments present in the living cells. During the process of digestion protein metabolites are formed which are the cause of the toxæmia.

Ordinarily the earliest signs of burn toxæmia appear about twenty-four hours after receipt of the injury. This latent interval is presumably the result of the manner in which the toxin is produced. Arising as the result of digestive activity of the cells underlying the burned skin, it requires an interval of time for the production of a quantity sufficient to produce symptoms. The usual signs are fever (up to 105°), vomiting, drowsiness, and convulsions. These, apparently, are evidences of the action of the toxin upon the central nervous system, and they constitute by far the commonest clinical picture. The action of the toxin is not, however, limited to the central nervous system; it produces changes in nearly all the tissues of the body, post-mortem evidences of which are to be found in the form of widely distributed focal necroses and ecchymoses. The post-mortem picture closely resembles that produced by diphtheria toxin. The central nervous system is apparently most susceptible to the action of the toxin, and symptoms referable to interference with its function usually dominate the clinical picture. Occasionally, however, the damage to other organs may be greater than usual. When this occurs to an extent sufficient to interfere with the function of an important organ (other than the brain), the usual picture of burn toxæmia, in which symptoms referable to the central nervous system

predominate, is replaced by one in which the symptoms are due to interference with the function of the organ involved. To the latter class belongs the case herein reported.

Since Curling,[2] in 1842, reported twelve cases of ulceration of the duodenum occurring in cases of burns, a great deal of attention has been attracted to this rare complication. Its occurrence is unusual. Erichsen[3] reported 2 cases amongst 68 patients; Ronchese[4] saw it once in 348 burned patients. In our experience it has been extremely rare, the present being the only case which has been recognized in the past twelve years. During this time there have been treated 567 patients with burns (138 of whom died). The ulceration usually occurs in the duodenum, but may take place in the stomach or upper part of the small intestine. The mechanism of the production of the ulcers, and their exact relationship to burns, are still under dispute. In my opinion it seems reasonable to assume that the action of the toxin produces focal necrosis and hæmorrhage in the duodenal mucosa, and that these areas are transformed into ulcers by the digestive action of the pancreatic juice.

Suprarenal hæmorrhage resulting from burns has been recognized even less frequently than has duodenal ulceration. From the researches of Weiskotten,[5] however, it appears likely that hæmorrhages or focal necroses in the suprarenals are the most common and most characteristic post-mortem findings of fatal burns. Large hæmorrhages, such as that reported here, are very rare. The unusual circulatory disturbances which characterized this case were almost certainly due to the profound disturbance of suprarenal function which must have resulted from the extensive hæmorrhages within the substance of the glands.

The importance and interest of the present case lies in the striking manner in which it emphasizes the toxæmic factor in burns. The recognition of burn toxæmia has led, in recent years, to a profound change in our conception of the pathological processes involved in this common form of injury. We no longer regard a burn as a type of wound to be dealt with by appropriate local treatment. On the contrary, our more recent conception of it is that of an injury which gives rise to a series of separate and extremely complex pathological processes (shock, toxæmia, sepsis, etc.), the most important of which are general rather than local in their action. Of these pathological processes, all, except the toxæmia, are met with in other surgical conditions, and constitute more or less familiar problems. The toxæmia, however, is peculiar to burns; it is, as yet, imperfectly understood, and is highly fatal, accounting, as it does, for approximately 75 per cent of the mortality. Further progress in the treatment of burns will come when the problem of toxæmia has been solved, so that the report of cases which may throw light on this obscure condition is of importance.

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AN INTERESTING CASE OF SPINA BIFIDA OCCULTA IN A YOUNG ADULT.

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and GEORGE ROBERTSON,
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The writers present this case from their hospital practice owing to the presence of somewhat unusual symptoms requiring differentiation from those arising out of serious injuries received many years ago.

History.—J.P., male, age 22, six years ago sustained, while attempting to stop a runaway horse, a depressed fracture of the left parietal region of the skull and a severe injury to the left lower limb in the region of the knee-joint. For the major injury we operated and removed a depressed area of parietal bone and, from beneath it, an extradural blood-clot. The unconsciousness and twitching of the right facial muscles, noted on admission to hospital, passed off in a few hours. Motor aphasia of a mild type continued for twenty-four hours after operation. For several days the grasping power of the right hand remained weaker than that of the left. The left knee-joint was swollen and contained excess of fluid; this was treated by fomentations while the whole limb lay on a posterior splint during convalescence from the head operation, which proceeded rapidly and uneventfully. Some months after his recovery he returned to work.

About five months ago, while walking in the street, his left leg lost all feeling and power and he fell to the ground. Almost immediately thereafter the sensation and power returned to the limb and he got up and walked away as usual. Similar attacks of weakness and loss of sensation of this limb have recurred at frequent intervals, sometimes as often as twice in half an hour, but more usually two or three times weekly. These attacks were as frequent when he walked on the smooth street pavement as when at work, when he trod rough roads in a coal mine. This disability was considered a source of danger to the lad while he worked underground near moving loaded trucks.

Frequent jerkings of the whole lower left limb and left arm were noted by the boy while he sat quietly in a chair or lay in bed. He had two recent attacks of feelings of 'coldness in both legs'; as the 'coldness' passed off he felt 'pins and needles'; the duration of these attacks was approximately five minutes.

Clinical Examination.—This revealed a condition of spina bifida occulta in the mid-lumbar region. The patient described the altered skin in the lumbar region as 'a birth mark'. The puckered, reddened, thin integument was tender to touch, and when slight pressure was made on palpating the left half of the area a pronounced jerk of the left lower limb occurred, accompanied by a distinct jerk of the left upper limb. The superficial and deep reflexes of the lower limbs were equal and normal, and no ankle-clonus existed. The limbs were equal in length, but the girth of the left limb at mid-thigh and

mid-calf level was less than that of the right limb by half an inch. A slight outward bowing of the upper third of the left tibia was apparent.

Motor Functions.—Only a slight weakness of the limb was noted. The knee-joint, which had suffered a severe injury six years previously, showed definite signs of rupture of the posterior crucial ligament.

X-ray Examination shows the 3rd lumbar vertebra possessing a typical bifid spine and an inequality in width of the two halves of the neural arch. A considerable deficiency of the body of the vertebra is also well shown (*Fig.* 607).

Diagnosis and Treatment.—The writers did not find it easy to make a straight diagnosis or to decide upon a straight line of treatment. A definite prognosis was likewise difficult, in view of the co-existence of the spinal defect and the ruptured crucial ligament of the knee-joint of the offending limb. It was plain that the knee-joint injury could not have caused the sudden attacks of anæsthesia and weakness of the limb resulting in the immediate fall of the patient to the ground.

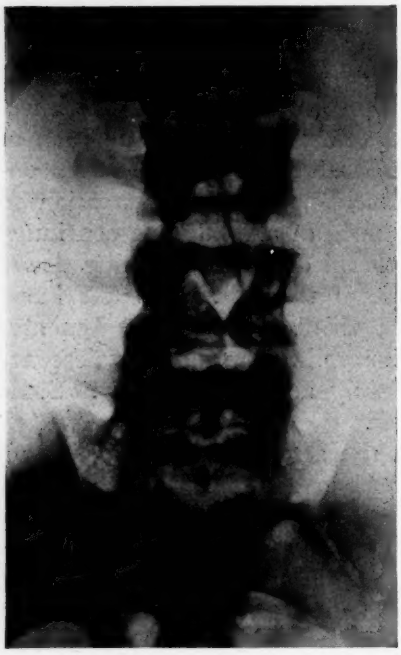

Fig. 607.—Skiagram showing the condition of the 3rd lumbar spine.

The areas of altered sensibility in the thigh and leg were definitely due to a lesion of the 3rd and 4th lumbar nerves in the caudal leash. The fact that the leg 'suddenly disappeared'—to use the patient's own words in describing his attacks—suggested that other divisions of the left half of the cauda equina were suddenly implicated in a momentary trauma at the level of the bony defect during active movements of the spine as a whole while the patient walked. The attacks complained of were of recent duration, while the knee injury had existed for six years. The spinal defect, though existent from birth, had progressively altered during the process of growth and ossification of the neural arch until the present age of the lad—22 years—when ossification was practically complete.

It was argued that the recent development of the attacks of weakness and loss of sensation of the left limb was connected with an increased drag upon the spinal meninges due to completed ossification of the two halves of the neural arch, which still allowed a process of spinal meninges to pass directly backwards to be attached to the cicatrix-like skin over the bifid spine of the 3rd lumbar vertebra.

The clinical fact that slight pressure upon the skin covering the bifid spine caused jerking of the limb proved that certain nerve filaments, teased from branches of the cauda equina and enclosed in the almost obliterated meningeal diverticulum, had been herniated through the bony defect posteriorly and become adherent to the integument.

The simultaneous jerking of the upper and lower extremity when pressure was applied over the occult spina bifida is more difficult of explanation, and the writers, suggesting that it indicated a conducting stimulus in the cord followed by a reflex action at a higher level, realize their inability to trace the paths with any degree of accuracy.

OPERATION.—We performed a limited laminectomy upon the neural arch of the 3rd lumbar vertebra. The bony area removed is shown in *Fig.* 608. The laminectomy was completed while the altered skin over the occult spina bifida remained attached to the intraspinal dura by the cord-like process of extraspinal membranes. When we were satisfied that sufficient bone had been removed, the cord-like structure was ligated and divided close to the spinal dura. Thus the remains of the original spinal protrusion were excised in one piece.

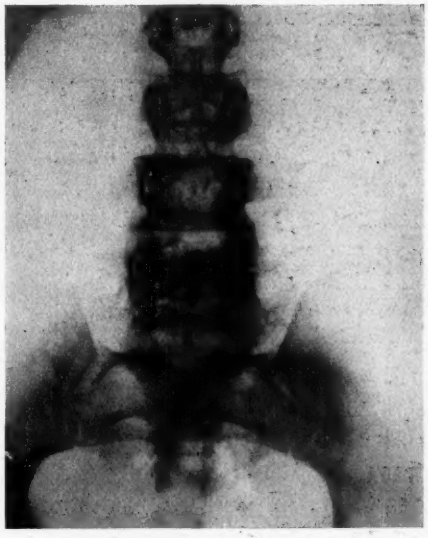

FIG. 608.—Skiagram showing the bony area removed at operation.

PROGRESS.—During convalescence an interesting condition developed—namely thrombosis of the left femoral vein in Hunter's canal; this was accompanied by a transient pyrexia (101°) of thirty-six hours' duration, and by œdema of the limb below the level of the thrombosis. It was at first difficult to understand why this venous thrombosis had occurred, but on further consideration we concluded that it was probably determined by mechanical trauma. The patient had lain in the usual position for laminectomy, a large cushion supporting the pelvis and elevating it from the level of the table; thus the lower limbs reached the foot of the table by a long incline. The anteroposterior mobility of the left knee-joint, owing to loss of the posterior crucial ligament, combined with complete muscular relaxation during anæsthesia, had probably allowed a degree of backward dislocation of the head of the tibia. A fixation girth applied to fasten the mid-thigh to the operation table also probably had a similar effect. A mechanical stasis plus a kink deformity of the popliteal vein was produced, and was followed by thrombosis. No other untoward symptoms developed, and the patient was allowed out of bed six weeks after operation.

RESULT.—No further disability of the limb has been complained of, and it is now many months since the operation. The areas of altered sensibility in the left thigh and leg have disappeared. No jerking of the left lower limb or arm has occurred either when the patient is at rest or when pressure is applied to the scar over the laminectomized area of the 3rd lumbar vertebra.

The authors are indebted to Mr. Archibald McKendrick, of Edinburgh, for the radiograms.

MACRODACTYLIA IN A CHILD, DUE TO NEUROFIBROMATOSIS (ELEPHANTIASIS NEUROMATOSA).*

By LAMBERT ROGERS,
ASSISTANT IN THE SURGICAL UNIT, THE WELSH NATIONAL SCHOOL OF MEDICINE, CARDIFF.

THE following case seems worthy of record because of the rarity of neurofibromatosis affecting the digital nerves.

Joan H. was born attached to a placenta prævia. When she commenced to crawl, her mother noticed that the thumb and first finger of her right hand were larger than those of the left, and that as she grew older the enlargement increased so that the disparity between these digits and the remainder became

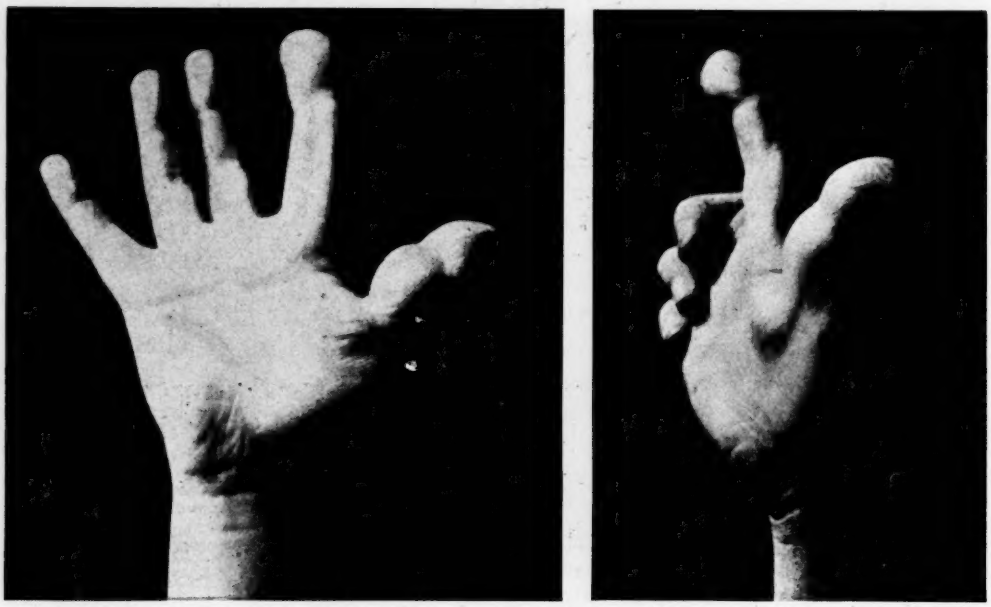

FIG. 609.—Illustrating the right hand of a girl, age 8, having enlargements of thumb and index finger. (Front and lateral views.)

more marked. Joan was one of a family of six children, all of whom were healthy and normal in every respect. Her mother had had no miscarriages.

The child was 8 years old when I first saw her, and her condition was then as shown in *Fig.* 609. The enlargements of the thumb and index finger had never pained her and were not at all tender. Except for the macrodactylia she was a normal and healthy child. A radiogram (*Fig.* 610) confirmed the clinical examination, which had shown the enlargement to be confined to the soft parts, the bones being unaffected.

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* This case was reported at a meeting of the Society of British Neurological Surgeons in London, on November 30, 1928.

On March 30, 1928, I removed the tumours from the thumb and first finger and, after cutting away redundant skin, closed the crescent-shaped incisions which had been designed so as to avoid scars on the ventral surfaces of the digits. The patient made a good recovery.

FIG. 610.—Radiogram of hand.

FIG. 611.—Appearance of tumours removed from thumb and index finger—the larger tumour was from the thumb

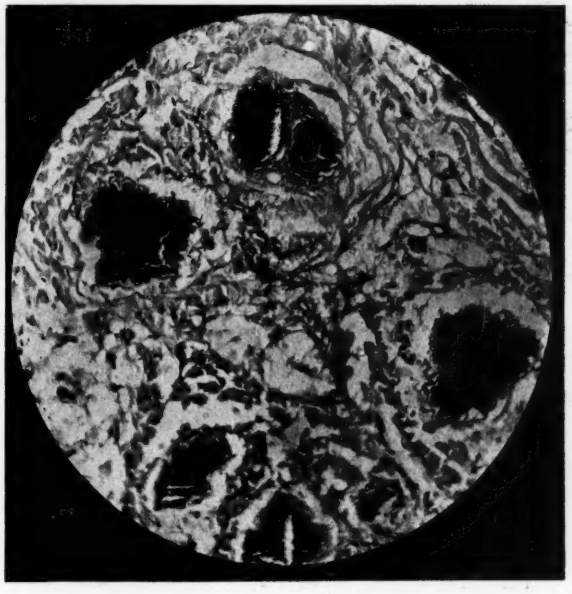

FIG. 612.—Microscopic appearance of cross-section of tumour from the thumb. (× 60.)

The gross appearance of the tumours shortly after removal is shown in *Fig.* 611, and their microscopic appearance in *Fig.* 612. Dr. J. B. Duguid, Lecturer on Pathology in the Welsh National School of Medicine, reported on these tumours as follows: "In the section are several nerve-trunks cut across and embedded in fibrous connective tissue and adipose tissue. There appears to be more of the latter than usual in neurofibromata, thus accounting for the softness of the tissue."

COMMENTARY.

In 1863, in his famous lectures on *Krankhaften Geschwülste*, Virchow[1] differentiated from the other forms of congenital elephantiasis one in which the nervous system participated. Some eight or nine years before, Valentine Mott,[2] of New York, had given to what was apparently the same condition the term 'pachydermatocele'.

In his now classical monograph, published in 1900, Alexis Thomson,[3] of Edinburgh, gave a most complete account of tumours of the peripheral nerves, dividing neuromata into true and false, and the false into four sub-groups, namely: (1) Circumscribed or solitary tumours growing from the connective tissue of nerve-trunks or of the ganglionic enlargement of nerves; (2) Diffuse overgrowths of the connective-tissue sheaths of nerves and of ganglionic enlargements of nerves—neurofibromatosis; (3) Traumatic or division neuromata; (4) Enlargement of nerves in leprosy, syphilis, or tuberculosis.

In the second of these sub-groups he placed elephantiasis neuromatosa or pachydermatocele, and he defined the condition as follows: "Elephantiasis neuromatosa includes those forms of neurofibromatosis in which, in addition to the cutaneous nerves, there is also a pronounced and diffuse overgrowth of the skin and subcutaneous tissue in a particular region or segment of the body." Thomson pointed out that a special feature of the elephantiasis is the extension of the fibromatosis from the endoneurial connective tissue of the cutaneous nerves to the tissues surrounding them.

Numerous examples of the different varieties of neurofibromatosis are quoted in the monograph. In the majority of the cases of elephantiasis the lower limbs were affected, in only one was there mention of the condition in the hand. That was a case recorded by de Morgan of a girl of 15 in whom the whole of one upper limb appears to have been involved, since the nerve-trunks of the arm and forearm were the seat of neurofibromatosis while the hand was in a state of elephantiasis. Sarcomatous changes ultimately occurred in a tumour of the radial nerve, and the arm was amputated.

There is only very slight resemblance, however, between de Morgan's case and the one here recorded, and apparently macrodactylia produced by neurofibromatosis is very rare.

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A CASE OF PRIMARY DOUBLE EPITHELIOMA.

By D. A. ABERNETHY,

ASSISTANT SURGEON TO THE RADCLIFFE INFIRMARY, OXFORD.

W. A., age 70, a police pensioner, was seen by me in July, 1927, complaining of a warty growth on the left side of the face and an indolent ulcer on the margin of the right ear. He stated that in 1919 he fell from a bicycle, cutting his face on the left side: the cut failed to heal entirely and a sinus persisted for seven years, from which exuded a little watery discharge. During the last twelve months a warty excrescence had been growing from the edge of the sinus, which had ceased to discharge. Meanwhile the patient had had for an indefinite time a lump in the edge of the pinna of the right ear. The overlying skin became thin and broke down, allowing a 'hard brownish stone' about a third of an inch in diameter to be extruded. There remained an ulcer which in four months had failed to heal—rather it had increased in size.

Fig. 613.—Section of growth from the face.

History.—The patient's past history revealed nothing but an evanescent attack of sciatica; the family history contains no case of cancer so far as can be ascertained. His father at least died of old age at 90, and he has several brothers and sisters alive and well.

On Examination. — There was present on the left side of the face, midway between the external auditory meatus and the external canthus, a papillomatous growth about three quarters of an inch in diameter and raised about the same distance above the surface. Its base was hard and indurated and there was no ulceration. At the highest part of the pinna of the right ear there was an ulcer an inch long and a third of an inch broad, with raised irregular edges and a raised indurated base. There were no palpably enlarged lymphatic nodes on either side.

Both these growths were removed at operation in July, 1927, when they were submitted to microscopic examination in the Pathological Department of the Radcliffe Infirmary.

A microphotograph of the growth from the face is shown in *Fig.* 613, while *Figs.* 614 and 615 are low- and high-power views of the ulcer from the ear. Both sections are obviously epitheliomatous and both show the presence of cell nests. Up to the present time there has been no recurrence.

DISCUSSION.

This case seemed to be worth recording because, although the coincidence of two or more carcinomata is not perhaps extremely rare,[1] here at least there can be but little possibility of a metastatic origin of the second. It was felt that the case ought to throw some light upon the etiology of cancer, inasmuch as two several sources of chronic irritation have, apparently, determined the growth of two carcinomata, the former taking seven years to produce the result, the latter an unknown but presumably much shorter time. It is obvious that the presence of one carcinoma does not immunize its possessor against the attack of another, but the paucity of these cases makes it evident that it does not predispose the patient towards such attack. This patient, therefore, must be congenitally abnormally liable to develop carcinoma, or during his lifetime he must have acquired this liability. In view of Miss Maud Slye's[2] work on the heredity factor in the production of cancers in mice it was hoped that this patient would have some history at least of cancer in his family, but he states that he never heard of any relation of his who suffered from it. If, however, the cancerous diathesis is in man a Mendelian recessive, as Miss Slye[3] has shown it to be in mice, this is not remarkable.

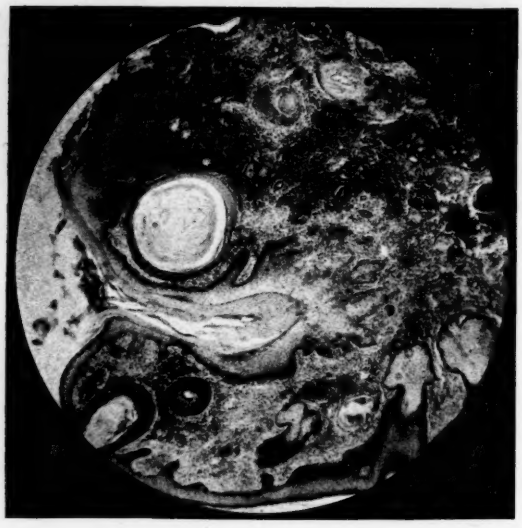

FIG. 614.—Section from the ear (low power).

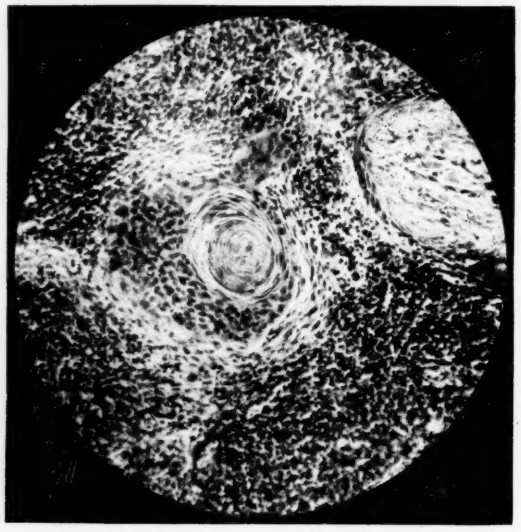

FIG. 615.—Section from the ear (high power). (× 135.)

The determining factor, then, must be explicable in terms either of his ordinary life or of his occupation. The former revealed no abnormality, the latter—service in the Police Force—involved at least constant and prolonged exposure to the weather. Such exposure may be supposed, by a constantly recurring restriction of the blood-supply to the skin of the face and ears, to have brought about

changes in the intracellular metabolism to compensate for the diminution in the supply of oxygen.

The investigations of Hopkins,[4] Joyet-Lavergne,[5,6] and others[7,8] into the functions of glutathione in normal cells, and its relative abundance in cancerous tissues, may be used to throw some light on the nature of this admittedly hypothetical change.

It is not unreasonable to suggest that the cell-content of this substance may be gradually raised throughout a period of years by recurrent eras of oxygen starvation. Then the long-continued subacute inflammation inaugurated by the trauma, slowly strangling these cells in a dense web of fibrous tissue, could weed out, as by natural selection, all the more normal of them. Only those could survive which, owing to their excessive glutathione content, were enabled to carry on their metabolism with so small an oxygen supply, and isolated, as many of them would be, from the restraining influence of their neighbours,[9,10] it is not too much to imagine that there should be produced an anaplastic race of cells of very high glutathione content, and therefore capable of thriving at the expense of more normal cells under very adverse conditions of oxygen supply—in fact a carcinoma.

SUMMARY.

1. A case of primary double facial epithelioma is described with microphotographs of the lesions.

2. There is reason to believe that trauma has played a great part in determining the incidence of these cancers.

3. An attempt is made to discuss the etiology, correlating some of the later investigations into the biology and biochemistry of carcinoma with the history and clinical findings in this case.

My thanks are due to Dr. W. T. Collier for the preparation and interpretation of the sections.

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TRAUMATIC DISLOCATION OF THE HIP-JOINT IN A CHILD.

By H. OSMONDE CLARKE,
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It is well known that traumatic dislocation of the hip-joint rarely occurs in children. For this reason isolated cases are frequently recorded in the literature. During the past twelve years at Ancoats Hospital two cases have been seen—one in 1916,[1] and another in 1927, which forms the subject of this note.

History.—A girl, age 3, was brought to the Casualty Department late one night, with the history of having fallen backwards while being carried on her brother's shoulders. Deformity of the left leg was noticed by the parents, and the child was unable to walk.

Examination.—There was an obvious dorsal dislocation of the head of the left femur. There were no signs of local bruising or undue swelling, but when handled the hip was slightly painful. Radiographic confirmation

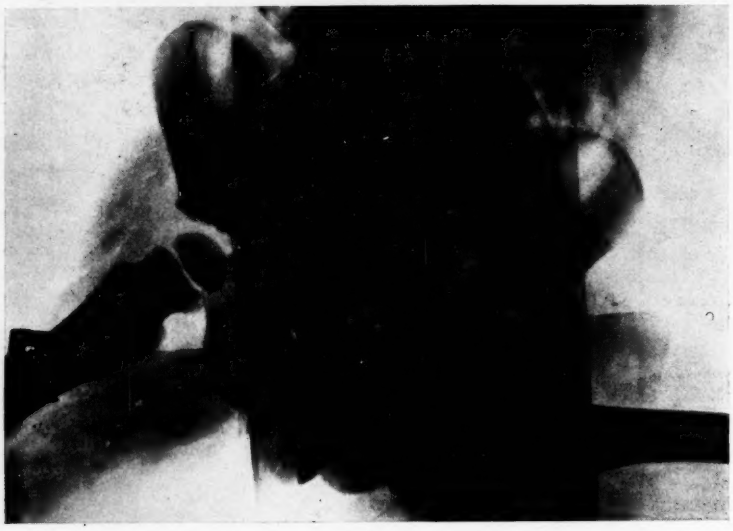

Fig. 616.—Radiogram after first attempt at reduction, showing left femoral head lying below acetabulum.

could not be obtained at the time, owing to the lateness of the hour. The other signs of local injury were so little marked that it was at first thought that the child had injured a hip which was already dislocated at the time of birth. On questioning the parents no definite evidence in favour of this view was obtained. It was decided to reduce the dislocation without waiting for radiographic confirmation.

Operation.—Under general anæsthesia ordinary manipulation, as used for congenital dislocation of the hip, was carried out, and an apparent reduction obtained. Owing to the filthy condition of the child, the limb was put

up in the standard position, as for the first stage of treatment of congenital dislocation, on an improvised splint, and she was admitted for the night.

A radiogram (*Fig.* 616) taken the following morning showed that complete reduction had not been obtained. A further manipulation under anæsthesia was then attempted, and the dislocation was reduced completely without difficulty. This was confirmed in a radiogram (*Fig.* 617) which also showed an acetabular development equal to that of the opposite side. This appearance disposed of the suggestion that the condition was of the congenital type. The limb was then bandaged to a splint in a position of full extension and slight abduction, and the child discharged from hospital.

FIG. 617.—Radiogram after second manipulation, showing complete reduction. Both acetabula and femoral heads appear normal.

SUBSEQUENT COURSE.—The patient was allowed to walk at the end of three weeks, and all traces of limping quickly disappeared. When examined nine months later she walked without limp, the hip-joint was freely mobile, and the radiogram showed no trace of abnormality.

Comments.—Special interest is attached to dislocation of the hip in early life, not merely because of its rarity, but because of the occasional development of secondary changes after reduction. This aspect has been referred to in a recent paper by Choyce,[2] who presents an analysis of fifty-nine cases published up to January, 1924, including one case observed by himself. Cases in which definite changes have developed appear to be three in number, reported by Elmslie,[3] Rehbein,[4] and Higgins.[5] It has been used somewhat illogically as an argument in favour of the traumatic theory of the causation of pseudocoxalgia—a common hip-joint affection seen between the ages of 5 and 10. On the other hand, it is much more logical to assume that the relation between pseudocoxalgia and an antecedent dislocation is a mere coincidence. In support of the traumatic theory of pseudocoxalgia, obliteration of the vascular supply in the ligamentum teres is often quoted. Such

arguments have little foundation in fact, for Walmsley[6] has conclusively shown that the vessels contained in it are present only in early life, and supply merely a tiny area in the head of the femur in the region of the insertion of the ligament.

My best thanks are due to Mr. Harry Platt for his kind permission to publish this case.

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A CASE OF POPLITEAL ANEURYSMS.

By G. C. E. SIMPSON, O.B.E.,
HON. SURGEON TO THE DAVID LEWIS NORTHERN HOSPITAL, LIVERPOOL.

NUMEROUS cases of aneurysm, varicose aneurysm, and aneurysmal varix have been recorded of recent years, and combinations of two of these are not infrequently brought to notice, but the presence of all three conditions in one segment must be most uncommon, and the result also seems to justify record.

HISTORY.—J. B., age 25, was wounded by a shell in May, 1917, in the Balkans. A depressed fracture of the left occipital area, and multiple shell wounds of the left leg and thigh, were dealt with. A minute wound 4 in. above the right knee on the outer side of the thigh appears to have attracted no attention, though the patient states that whilst in hospital at Salonica, about three weeks after his wound, he noticed a buzzing sensation in the thigh. He did well, his wounds healed, and his right hemianopsia disappeared.

In July, 1919, he came under observation for Jacksonian fits occurring at moderate intervals and preceded by a definite visual aura—"When he lost sight of anyone walking on his right side, he at once lay down." During the examination of his legs, he called attention to a buzzing in his right vastus externus, and on investigating this a marked thrill was felt—most marked in the popliteal space and near the adductor tubercle. Here, also, there was marked pulsation and a loud systolic bruit conducted to the groin and to the foot. A communicating vein from the popliteal space ran round the inside of the thigh to join the saphenous at Scarpa's triangle. It was $\frac{3}{8}$ in. in diameter and slightly tortuous, very thick-walled, and pulsated strongly with thrill and bruit. The other superficial veins were but slightly enlarged; the tibial pulses were slightly impaired. The general blood-pressure was 140 to 150 mm.—that in the right leg about 5 mm. less than in the left, but the record in the right thigh was over 200 mm.

Operation was advised in view of the marked tension of the popliteal space, and of the recent occurrence of cramps in the affected leg.

PREPARATION.—The patient was asked to flex his leg and knee, and hold it as fully flexed as possible for at least an hour twice a day, and to increase the time each day. At the end of the week he was able to keep it so flexed for long periods without discomfort. The effect on the tumour was very definite: the veins lessened, the thrill was less, the popliteal space became softer, and the pulsating area near the adductor tubercle was now recognizable as a definite tumour (X rays showed a minute metallic body here).

OPERATION (Aug. 15, 1919).—Ether anæsthesia. A very large and saccular vein lay just below the deep fascia, and rapidly filled until its diameter was about 1½ in.; this was retracted with the nerve, and the popliteal vessels were exposed and clamped below with Dieffenbach's clips, the whole area being smeared with vaseline. The aneurysm was drawn out and the popliteal vein then separated from its close attachment to the artery—at least dorsally, for posteriorly the popliteal vein was not attached to the artery, but to another vein. It was cleared from this, and the ⅝-in. slit in the vein was sutured with fine vaselined silk in two layers. The apex of the arterial aneurysm on the inner side, which was pyriform, and measured about 1 in. by ¾ in., was cut away, a little clot turned out, the opening into the artery sutured, and the walls of the sac were sutured over as extra protection. (The foreign body in the apex was a thin scale of metal, its longest diameter being $\frac{1}{16}$ in.)

Attention was now turned to the external aperture in the artery; superficially, this had communicated directly with the popliteal vein, forming a true aneurysmal varix; deeply, however, it communicated with a sac of about 1½ in. circumference, which in turn communicated with a large vena comes, above and below (*Fig.* 618). In the anterior wall of the sac the wall of this vein could be traced. The appearance on cross-section would have been trifoliate—the inner circle popliteal artery, the outer popliteal vein, and the anterior varicose aneurysm. The vena comes was ligatured above and below; part of the wall of the sac was cut away, retaining the connection of the residue with the arterial orifice, and the latter was sutured, the sac then being brought over as a patch. At this stage some bleeding from the sac wall occurred, and, as far as could be determined, the superior external articular branch of the popliteal communicated with the sac of the varicose aneurysm. The operation lasted an hour and a half; the patient's condition was good.

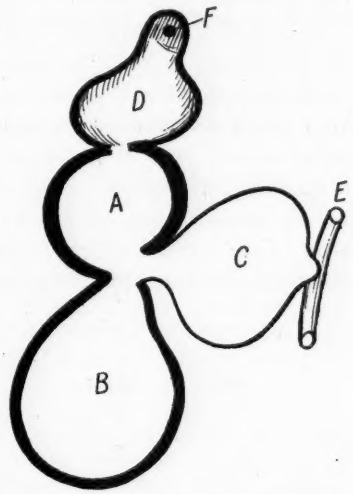

FIG. 618.—A case of popliteal aneurysms. A, Popliteal artery; B, Popliteal vein; C, Varicose aneurysm sac; D, Aneurysm sac; E, Vena comes; F, Foreign body.

Presumably the foreign body passed through the popliteal vein, caused a partial lesion of the vena comes, and then passed through the artery. Anteriorly the popliteal vein and artery became united, posteriorly the vena comes lay between them, and here a sac was formed uniting to both artery and veins. On the inner side of the artery an arterial

aneurysm was formed, either from a diffuse aneurysm or from dilation of a scar in which the foreign body was embedded.

AFTER-TREATMENT.—The leg was kept with the knee slightly flexed and the foot elevated. Progress was uneventful, there being no numbness, coldness, or loss of power of movement, nor were the tibial pulses impaired. The patient was discharged five weeks later, and was told to wear an elastic stocking.

PROGRESS.—*Four months later* he complained only that the foot was rather cold, and the leg was more readily tired than the other. The enlargement of the veins had entirely disappeared. Most interesting is the fact that he has only once had a fit in the four months, and that he states that his eyesight is stronger. This is undoubtedly to be attributed to the disappearance of the vascular changes secondary to his aneurysm. *Nine years later* (*April* 26, 1928), he states that the leg never troubles him and never swells. There is no sign of aneurysm, and, except for a dilation and thickening of the upper four inches of the communicating vein joining the saphenous from the popliteal space, no difference between the two legs can be detected. Blood-pressure is about 130. He has had no further fits, although if he becomes excited he suffers from a right frontal headache and is nervous. He has asthma in the spring.

NOTE ON COMPRESSION TREATMENT.—I have now tried this as a preliminary to operation for aneurysm in three cases—aneurysm of the common and deep femoral secondary to suppuration after ligature of the femoral for popliteal aneurysm (ascribed to the strain of marching); aneurysm of the brachial and ulnar following a severe contusion in a syphilitic; and the present case. In none of these has the collateral circulation given rise to any anxiety—sensation, power of movement, and pulse have been good throughout. This was most noticeable in the patient with femoral aneurysm, where the tibial pulses were barely perceptible before operation, and where the patient commented after operation on the fact that his foot had been quite comfortable—not painful and dead as after the previous operation. (He is also quite well nine years afterwards.) I most certainly consider this an advisable routine preliminary to operation on aneurysms.

REVIEWS AND NOTICES OF BOOKS.

Surgery: its Principles and Practice; for Students and Practitioners. By ASTLEY PASTON COOPER ASHHURST, A.B., M.D., F.A.C.S., Professor of Clinical Surgery in the University of Pennsylvania. Third edition, thoroughly revised. Royal 8vo. Pp. 1179 + xi, with 1046 illustrations and 15 coloured plates. 1928. Philadelphia and New York: Lea & Febiger. $10.

IN the first edition of this work (1914) the author acknowledges his debt to the text-book of John Ashhurst, jun. It is pleasing to think that that name, so long associated with American surgery, should still adorn a great text-book, and serve for yet another generation of students and practitioners. For it is a good text-book, and its teaching is sound and sane. It has been almost completely rewritten, though this has not increased its size. The illustrations are good: the radiographs are clear, the ordinary photographs of clinical interest are to the point, and the line drawings are simple in design. There are some new coloured illustrations, apparently from water-colour drawings, notably two beautiful examples of breast cancer.

For its size the book is wonderfully complete, and would give a student a thorough foundation for the study of surgery. The chapters on fractures and joints are very complete. We note, however, that in discussing supracondylar fractures the well-known advice of acute flexion is rather over-emphasized. "It [the fracture] is kept reduced by hyperflexion (flexion as acute as possible) (Dauvergne, 1873)", and in the accompanying illustration on the next page the amount of flexion would certainly be dubbed dangerous in the English law courts. An interesting paragraph on intestinal localization on page 855 might well be copied into our text-books. A book confidently to be recommended to both students and practitioners.

La Pratique chirurgicale illustrée. By VICTOR PAUCHET. Royal 8vo. Fasc. 12, pp. 230, with 194 illustrations drawn from nature by S. DUPRET. Fasc. 13, pp. 267, with 225 illustrations by S. DUPRET. 1929. Paris: Gaston Doin et Cie. Fasc. 12, Fr. 50; Fasc. 13, Fr. 60.

FASCICULUS 12 has been produced by Dr. Pierre Mornard, and contains articles on no fewer than twenty-four subjects. For the most part the volume deals with elementary surgery, such as removal of lipomata and cysts, ingrowing toe-nail, exostoses, tendon lengthening, and the like. Dr. G. Laporte has contributed a useful article on sacral anæsthesia. As usual, these simple procedures are fully—perhaps too fully—illustrated by Monsieur S. Dupret. We note, as we have noted before, that the author returns to subjects which he has dealt with in other volumes—for example, adenoma of the breast and ischiorectal abscess. At the end of the volume there is a table giving the subject matter in each of the volumes published. It would be an advantage to the student if the articles dealing with one branch of surgery were collected into one volume—for example, the colon finds a place in all but two of the volumes.

Fasciculus 13 deals with mixed tumours of the parotid, plastic resection of ribs, biliary drainage for pancreatitis, gastropexy, presacral tumours, colon resections, diverticulitis, fæcal fistula, closure of colostomies, strangulated femoral hernia, and resection of the hypogastric plexus. Kehr's methods of subserous biliary drainage are well described, and also an ingenious method of anastomosis between the common duct and duodenum.

An alternative method to the use of an enterostome for closure of a colostomy which avoids stenosis at the site of closure is described. The method is simple and avoids opening of the peritoneal cavity. The chapter on diverticulitis makes use

of radiographic illustrations by Spriggs, and describes a very elaborate surgical procedure to establish continuity with the rectum after sigmoid resection ; a loop of ileum is isolated and eventually employed to establish continuity between the transverse colon and rectum. The procedure seems to be ultra-heroic. The volume is full of interest to the surgeon and bristles with original ideas.

Die Chirurgie: A System of Surgery. Edited by Professors M. KIRSCHNER and O. NORDMANN. Fasc. 23, being a part of Vol. II. Imperial 8vo. Pp. 315, with 169 illustrations and 7 coloured plates. Berlin and Vienna: Urban und Schwarzenberg. M. 20.

THE present section is entirely devoted to the surgery of the joints and the synovial membranes, and is written by Professors Seifert, Stahnke, and König, of Wurtzburg. It is divided into two main portions, the first dealing with non-tuberculous and the second with tuberculous affections. After a few introductory pages on anatomy, physiology, and methods of clinical examination, there follows a description of injuries to the joints. The description of the dislocations of the hip is particularly well illustrated by recent X-ray pictures. Methods of treatment are considered in a separate section, and this has many drawbacks, both from the consideration of convenience of reference and of completeness. The description and illustrations of osteo-arthritis are specially worthy of commendation, the coloured plates being some of the most beautiful we have ever seen. The value of the pictures in many instances would be greatly increased by more ample legends or references to the text. The difficult subjects of osteochondritis dissecans and the various types of quiet necrosis of the cartilages are figured and discussed very well. The final section on tuberculous diseases of joints is quite equal to the general standard of the work. As we have had occasion to remark in reviewing other parts of this great and monumental work, we think that the description of methods of treatment is not nearly so full or detailed as those on pathology.

Der Technik der Eingriffe am Gallensystem. By Dr. PETER WALZEL. With an Account of the Surgical Anatomy by Dr. OSCAR SCHUMACHER. Royal 8vo. Pp. 240, with 108 illustrations. 1928. Vienna: Julius Springer. Sewed, 60s. (M. 36); bound, 64s. (M. 38.60).

THIS volume is a monograph dealing with the various surgical aspects of the gall-bladder and its ducts. It may be said to represent the views and the teaching of von Eiselsburg's school, and, while the text contains numerous references to related work by various authors, the volume must be regarded as a presentation of the opinions and technique of an individual school. It is evident that it is not intended to be an exhaustive account of a wide variety of opinions ; it is an individualistic production, and therefore most interesting, stimulating, and helpful.

After an introduction which is explanatory of the general lay-out of the volume, and an acknowledgement of the help derived from various sources, the subject is introduced by a chapter dealing with the general operation questions which concern gall-bladder surgery. The advantage of certain special instruments is discussed, and attention is drawn to the value in dissection of a modified type of Kocher's dissector, which is light, perforated, flexible, and evidently very useful in the delicate procedure of separation of the bile-duct, the cystic duct, and the associated blood-vessels.

The immediate pre-operative period is the subject of a helpful summary. The cold infusion of senna leaves combined with manna and magnesium carbonate is recommended as the pre-operative purgative. Certain opinions in this country will be critical of the dosage employed (1 to 2 oz.), in view of the increasing tendency to lessen pre-operative dehydration.

The problem of the jaundiced patient is fully discussed, and Dr. Walzel expresses himself as strongly in favour of blood transfusion as the most efficient preventive of post-operative bleeding. Serum and calcium therapies are mentioned, but they are not considered on a parallel with blood. We have not been able to discover any

reference to the value of the sodium citrate injection, a method which we believe to be of great value as a preventive of hæmorrhage after operation. Perhaps it is not sufficiently appreciated that the danger lies not so much in a wound hæmorrhage as in the progressive oozing from the mucous membranes of stomach and intestine which appears, it may be, as late as the tenth or twelfth day after operation. The preparation favoured for the skin is a compound containing iodine 5 parts, liquid paraffin 20 parts, benzoin 100 parts.

The matter of the most suitable anæsthetic is a question which interests all abdominal surgeons; the author gives his opinion in favour of ether preceded by the usual atropine and morphia injection. The use of chloroform in the presence of jaundice is condemned. In peculiarly anxious cases, such as those of carcinoma of the pancreas or of the duodenal papilla with secondary jaundice, the advantages are discussed of the intravenous injection of glucose controlled by insulin.

The choice of incision is gone into with great care, and on the whole the transverse incision (Querschnitte) is favoured, for the reason that it affords facility of access while subsequent closure can be made reasonably strong and complete.

Some one hundred and fifty pages of the volume deal in close detail with the technique of the various operations on the gall-bladder and its ducts. The consideration is as complete as it would seem possible to make it, and it must be a very rare condition which does not receive attention in this most excellent account. The steps in the operation are rendered clear, and therefore peculiarly helpful, by the addition of a large number of excellent figures—drawings which have obviously been made in the operating theatre.

The peculiar dangers and difficulties of gall-bladder operations are splendidly detailed and portrayed, and the reader instinctively feels that here is a practical treatise written by one who has encountered the difficulties which every surgeon is liable to meet. There is one criticism which we think it right to enter, and it is that the operation of cholecystostomy receives less attention than it deserves. In spite of the popularity which attaches at present to cholecystectomy there are circumstances under which cholecystostomy is a necessity, and the value of the volume would have been enhanced by an inclusion of the merits, the indications for, and the technique of this operation.

A valuable addition to the volume is the section on surgical anatomy written by Dr. Oscar Schumacher. It is perhaps the best account of the anatomy of the region which we have seen. The various abnormalities, not infrequent in this region, are fully discussed, and the matter is illuminated by a complete series of excellent drawings.

The volume is a notable addition to the surgical literature of the biliary system, and its supremely practical nature enhances its value to the operating surgeon.

A Text-Book of Surgery: for Students and Physicians. By W. Wayne Babcock, A.M., M.D., F.A.C.S., Professor of Surgery and of Clinical Surgery in the Temple University; Surgeon to the Samaritan Hospital and to the American Hospital for Diseases of the Stomach, Philadelphia. Royal 8vo. Pp. 1367, with 1041 illustrations and 9 plates in colour. 1928. London and Philadelphia: W. B. Saunders Co. 45s. net.

It is unusual at the present day for an individual to take upon himself to compile unaided a book which will cover the whole realm of general surgery. Professor Babcock has undertaken this almost impossible task, and the book he has written is a great achievement, and a greater testimony to his courage. In his introduction he suggests that it is an expression of his reaction to the past, and especially to the present. It certainly gives a good idea of the surgery he is teaching and of current surgical practice in America. On reading through the book, however, one wonders for which section of the medical community the work has been intended. It is presented as "a text-book for students and physicians". For the most part the text is written in the form of very slightly elaborated lecture notes, and seems to be rather too condensed—too much of a synopsis—for the ordinary student. Large sections of it deal with operative technique and anæsthesia, which the average

student does not need. There is, on the other hand, not nearly enough detail for the student working for the higher examinations, nor enough guidance for the physician if by chance he were to consult a book on surgery in his deliberations with regard to treatment.

The work consists of four parts: general surgery, the surgery of systems, surgical technique, and regional surgery. One feels that the author has tried to include too much, and the result has been a sketchy review of a great field. As a book of reference it is useless.

It is valuable in that an attempt has been made to emphasize the practical side of the subject; and in the description of cases and of technique the author has been tremendously helped by the wonderful illustrations prepared by Mr. McNett, of the Max Brödel School. The illustrations are not only good but very numerous, and the volume comes well up to the usual high standard of its publishers.

Précis de Pathologie chirurgicale. By BÉGOUIN and F. PAPIN, HENRI BOURGEOIS, PIERRE DUVAL and J. GATELLIER, GOSSET and D. PETIT-DUTAILLIS, E. JEANBRAU, LECÈNE, LENORMANT, R. PROUST and R. SOUPAULT, L. TIXIER and M. PATEL. Fifth edition. Demy 8vo, in 6 vols. Pp. 5542, with 1918 illustrations. Vol. I, General Surgical Pathology, Diseases of the Tissues; Vol. II, Head, Spine, Pelvis; Vol. III, Neck, Thorax, Mammary Glands; Vol. IV, Abdomen; Vol. V, Male Genital Organs, Urinary Pathology, Gynæcology; Vol. VI, Fractures and Dislocations, Acquired and Congenital Affections of the Limbs. 1928. Paris: Masson et Cie. Each volume, sewed, Fr. 45; cloth, Fr. 55. Complete, sewed, Fr. 270; cloth, Fr. 330.

THIS, the fifth edition of this précis published during the last twenty years, has been entirely reset, and is in many parts a new work, forming one of a long series comprising the whole range of medical science from biology to operative technique. It is written for medical students and general practitioners, and is divided into six volumes, each of which may be bought separately. It deserves success in that it attempts to bring surgery and pathology into line, and descriptions of operative technique are included where they illustrate or explain pathological details; but it is too voluminous to be a text-book of surgical pathology for the ordinary student, and too theoretical and lacking in practical suggestions to be used by the general practitioner. It represents, however, a very fair comment on the more staid French surgery of to-day, and so should have much interest for English surgeons.

The pathology of the earlier stages of any disease and to a large extent true cellular pathology have not been adequately treated, and the general impression of this book, furthered by the illustrations, is that most diseases are seen by the French surgeons at a more advanced stage than is usual in England. It is interesting to see that in carcinoma of the breast radium is reserved for inoperable cases or recurrent nodules, and that in a book on pathology seventy-four pages are devoted to traumatic fractures of the femur, and that only four are spent in the description of gastric and duodenal ulcers.

For a précis of surgical pathology too much has been attempted, but as a somewhat diffuse introduction to surgical pathology for the student it may serve its purpose.

Les Tumeurs villeuses du Rectum. By ANDRÉ LAMBLING, Ancien Interne des Hôpitaux de Paris. Medium 8vo. Pp. 118, with 15 illustrations. 1928. Paris: Masson et Cie. Fr. 18.

THE author of this book has furnished us with a very clear account of the pathology of those interesting neoplasms, the villous tumours of the rectum. Their etiology is elaborately discussed, though it is pointed out that their origin is enshrouded in as much mystery as are other new growths met with in this locality. Symptomatology is considered under the heads of hæmorrhage, alteration in the character of the stools, the secretion of an abundant watery discharge, and extrusion of the tumour through the anal orifice during defæcation. Three types of villous growth are described: the pedunculated tumour, the sessile growth, and diffuse multiple vegetations. It is

pointed out that the latter variety is much more commonly met with than is generally supposed. Histologically, three varieties are described—namely, the benign villous tumour, the villous tumour undergoing malignant degeneration, and the malignant villous tumour. The microscopical appearances of each variety are carefully described and depicted in excellent drawings of microphotographs. Despite the various arguments advanced by the author in support of this classification, we do not think that there is real justification for it. Villous tumours, even when microscopically proved to be benign, tend to recur after local removal, and in such instances the recurrent growth is generally found to be malignant. It is probable, therefore, that malignant villous tumours are in the first instance benign, and that the benign villous tumour is really a precancerous condition.

Treatment is very fully considered under three heads : radium and radiotherapy, electrocoagulation and fulguration, and removal by surgical intervention. The author's experience of the treatment of these tumours by radium has not been encouraging. He has found that in the malignant forms deep infiltration has progressed, and in many instances cellular proliferation appeared to have been accelerated. In the treatment of benign tumours he considers that electrocoagulation and fulguration deserve consideration, but points out that these methods are only applicable when the tumour is very small, is distinctly pedunculated, and is within easy reach. Removal by surgical intervention is, in his opinion, the method of choice. Three operative procedures are available : excision *per vias naturales*, resection with end-to-end anastomosis, and amputation of the rectum either by the perineal route or by the abdominoperineal method. For benign growths local excision gives excellent results provided that a wide collar of mucosa surrounding the origin of the pedicle is also excised. For malignant cases that are not too extensive, resection with end-to-end anastomosis is preferred to perineal excision, on the ground that the sphincters are thereby preserved. With this view we do not agree, because, under such circumstances, the sphincters are preserved at the expense of probable recurrence. Neither do we agree that extirpation by the abdominoperineal route should be reserved for advanced cases, because we consider that the widest possible removal in the early phase of a malignant growth is the best safeguard against recurrence.

At the end of the book full details of thirty-seven cases are given recording the nature of the treatment adopted and the end-results. We regard the volume as a valuable contribution to our knowledge of the pathology of villous tumours of the rectum and well worthy of careful study.

Old Masterpieces in Surgery. By ALFRED BROWN, M.D., Omaha, Nebraska. Imperial 8vo. Pp. 263 + xviii, with 53 illustrations. 1928. Omaha : Privately printed.

THIS volume of essays originally appeared as separate chapters, spread over four years, in *Surgery, Gynecology and Obstetrics*. The author's description of his own articles is that of being "a collection of thoughts and observations engendered by perusal of some of the works of our forbears in surgery". No attempt has been made to give any complete account of the old surgeons or their books. The author contents himself with giving a short word-picture of the man and of the times in which he lived, and we confess that the collection of essays thus brought together is of very great interest whether the reader is an historian or a medical practitioner.

The forty-eight essays begin with a consideration of Soranus of Ephesus about A.D. 120, and then proceed through the centuries, concluding with Pierre Dionis of the seventeenth century. In this way the progress of surgery throughout the period of nearly fifteen hundred years is described. We are made to realize many of the stages of conflict between tradition and original observation. Some of the master surgeons of their day, such as John Arderne, Paracelsus, Vesalius, Paré, Tagliacozzi, Thomas Vicary, Thomas Gale, William Clowes, and Cheselden, are fairly familiar to English readers ; but there are many workers and writers from Italy and the Low Countries introduced to us with whom we are much less familiar. One of the most interesting chapters is that dealing with lithotomy and the lithotomists. The

cutting for stone is said to have been practised even among the early Egyptians; it was certainly widely used in India. In the present work the principal consideration is given to the operation which was done in the Middle Ages by those who made it a special cult, such as Collot and Frère Jacques. A most gruesome picture is given of the perineal operation being performed by the latter amid a company of divines. The scope of the work extends rather beyond that of surgery, inasmuch as it includes several chapters on midwifery and also one on Harvey's circulation of the blood. Not only are the articles written in a most scholarly style, but they are beautifully printed and accompanied by a good selection of illustrations, showing the title-pages or the instruments delineated by these old works.

A Study of Intracranial Surgery. By HUGH CAIRNS. Royal 8vo. Pp. 83, with 37 illustrations. Issued by the Privy Council Medical Research Council. 1929. London: H.M. Stationery Office. 3s. net.

DURING his tenure of a Rockefeller Fellowship Mr. Cairns served for the year 1926–7 as an assistant resident surgeon in Dr. Harvey Cushing's clinic at the Peter Bent Brigham Hospital, Boston. In some 80 pages of text and 30 of illustrations he gives an account of the work of the clinic in the surgery of intracranial tumours during that time. The Medical Research Council has deserved the gratitude of surgeons for publishing as a Special Report this monograph on the activities of a clinic that has earned and holds a unique prestige in the surgery of the brain. Mr. Cairns writes in a clear and interesting way; he allows it to be plain that he is an enthusiastic admirer of Dr. Cushing, but there is nothing in his expression of this wholesome sentiment to make one doubt his being a shrewd and able observer. During the year in question there were dealt with in the clinic 176 cases of cerebral tumour in which the diagnosis was confirmed histologically. Using this material freely for the illustration of his theme, Mr. Cairns gives a valuable account of the methods of diagnosis and treatment employed, and in doing so he writes, as it were incidentally, a fairly comprehensive, though not of course a minutely detailed, thesis on the surgery of cerebral tumour. The circumstances are not such as to call for a critical examination of the methods described: it is enough to say that the narrative is worthy of its subject, and that it deserves the attention not only of specialists but also of all who are interested in the evolution of modern surgery.

Medizinische Praxis Sammlung für ärztliche Fortbildung. Vol. IV. By Professor WERNER KÖRTE, Berlin. Demy 8vo. Pp. 183 + xii, with 26 illustrations. 1928. Dresden and Leipzig: Theodor Steinkopff. Sewed, M. 10; bound, M. 11.50.

THIS small book contains a review of German knowledge and practice in diseases of the bile-passages. The subject is dealt with in a thorough and careful manner with reference to original authorities. Besides chapters on the indications for operative treatment and its technique, there are short chapters on the bacteriology of the bile-passages, liver function testing, and duodenal intubation. Altogether a useful monograph.

Tactique opératoire des Voies biliaires. By W. M. STERN, Ancien Interne des Hôpitaux de Paris; and R. FOURCHE, Ancien Prosecteur de la Faculté de Médecine de Nancy. Royal 8vo. Pp. 288 + viii, with 203 illustrations. 1929. Paris: Gaston Doin et Cie. Fr. 75.

THIS monograph is one of a series on *La Tactique opératoire* published under the direction of MM. Robineau and Stern. The essential feature of these volumes is that the operative measures described all have a direct relation to various degrees of pathology in the region dealt with, and the description of each procedure is prefaced by a brief account of the clinical features of the case in hand. The monographs are thus intended to help the practising surgeon and not as manuals for an operative surgery class. The authors of this volume have succeeded admirably in portraying the various operations now carried out on the biliary tract, working up from the

simplest to the most difficult and intricate type of case. The descriptions are clear and concise and bear the imprint of much practical experience, and the drawings, which occupy more than half the space of the volume, are of an exceptionally high standard. Special mention must be made of the section dealing with operations for stone in the common bile-duct, the numerous operative procedures for which are treated with great clarity and precision. The book will be welcomed by all who are interested in abdominal surgery.

The Duodenum: Medical, Radiological, and Surgical Studies. By PIERRE DUVAL, JEAN CHARLES ROUX, and HENRI BÉCLÈRE, of the Surgical Clinic, Faculty of Medicine, Paris. Translated by E. P. QUAIN, M.D. Royal 8vo. Pp. 212, illustrated. 1928. London: Henry Kimpton. 21s. net.

THIS book is a careful study of the duodenum compiled by a physician, a surgeon, and a radiologist, with the help of a chemist. It deals fully with the more obscure conditions which are met with in that part of the gastro-intestinal tract, and considering the diverse qualifications of the authors it is not surprising that every condition which is mentioned is discussed exhaustively.

'Essential' and cholecystitic periduodenitis and compression of the third part of the duodenum by the mesenteric pedicle are said to be conditions which ought to be diagnosed from their symptoms and particularly from their X-ray appearances. When we meet a statement of this kind we begin to wonder if the authors are not, to some extent, overstating their case. And the same feeling continues as we read further. A gloss of exaggeration as to the frequency, importance, and need for surgical relief continues. Leaving this aside there is some useful information to be gleaned from the book. The X-ray appearances of all these duodenal conditions are fully portrayed, and the outline drawings which are given with every radiogram make their interpretation perfectly straightforward.

The final chapter, perhaps the most valuable, on intoxication in duodenal retention, covers the subject very fully, experimental findings are quoted freely, and the conclusions drawn from them are convincing.

The book is very well put together, and has been translated in such a way as to read fluently. The drawings and X-ray photographs have been well reproduced. Altogether it is a work which will repay the time spent in reading it, for, in spite of unequal and perhaps undue emphasis, it throws a good deal of light on the possible pathological conditions which are to be met with in the duodenum and attempts to classify their somewhat vague clinical manifestations.

Index of Differential Diagnosis of Main Symptoms. Edited by HERBERT FRENCH, C.B.E., M.A., M.D., F.R.C.P., Senior Physician to Guy's Hospital; Physician to His Majesty's Household, etc. Fourth edition. Super royal 8vo. Pp. 1180, with 701 illustrations (179 coloured). 1928. Bristol: John Wright & Sons Ltd. £3 3s. net.

WHEN a work of this size and importance has reached the impressive figure of thirty-nine thousand, distributed over four editions and several reprints, it is unnecessary to discuss its value. The book, which first appeared in 1912, has actually been out of print for five years, in spite of the fact that the third edition was reprinted no fewer than five times.

Although twenty physicians and surgeons have collaborated in the writing, yet the Editor has himself taken by far the largest share in contribution. The authors of the articles on surgical subjects are Professor Gask, Messrs. Rowlands, Jocelyn Swan, Mollison (ear), and Hastings Gilford (dwarfism and gigantism), of whom the first-named takes much the largest share.

The plan of the book is to consider all the leading signs and symptoms of disease, these being arranged in alphabetical order. Each symptom is discussed in relation to diagnosis. Thus in the early pages we have 'accentuation of heart sounds', 'acetonuria', and 'albuminuria'; and later on, 'limping in children', 'liver, enlargement of'; and at the end, 'vomiting', 'wheals', and 'X-ray diagnosis'. Naturally and inevitably this involves a good deal of repetition and cross-reference. But as

the authors of the work have not grudged the time and trouble involved in looking at the same subject from many different points of view, we think that readers can only be grateful to them for the endless pains taken in presenting the subject. Some subjects like dwarfism are simple and self-contained and the discussion of diagnosis is covered in a few pages. Others, such as ureteric calculus, must be considered under many different headings—for example, X rays, colic, etc.

The number and excellence of the illustrations greatly add to the value of the work, the colour pictures and printing being very beautiful and the paper so good that even the finer points of radiograms are well shown.

The very carefully arranged index which occupies 227 pages is an essential feature of the book, because it enables the reader quickly to find the different sections dealing with various subjects in which he is interested. We have no hesitation in saying that every practitioner and specialist ought to have access to this book.

Diagnostic et Thérapeutique par le Lipiodol. By J. A. SICARD, Professeur à la Faculté de Médecine de Paris; and J. FORESTIER, Ancien Interne des Hôpitaux de Paris. Medium 8vo. Pp. 370, with 49 plates. 1928. Paris: Masson et Cie. Fr. 50.

PROFESSOR SICARD and Dr. Forestier have given us in this volume a most interesting and exhaustive study of the diagnostic and therapeutic uses of lipiodol. This substance, which is an inert vegetable oil containing 40 per cent of iodine, is remarkably opaque to the X rays, and as it can be injected, seemingly with complete safety, into almost any part of the body, it can be used in all kinds of situations for radiographic examinations, from the localization of spinal tumours down to the determination of permeability in the Fallopian tubes. The popularity which it has already achieved may be gathered from the fact that no fewer than 66 of the 370 pages of this volume are devoted to a bibliography in which reference is made to nearly 900 published papers.

In the first chapter the chemical and physical properties of lipiodol are given in detail, and this is followed by an account of its behaviour in the tissues, and of the mode of elimination of the contained iodine when it has been injected into various parts of the body. The second chapter is devoted to the employment of lipiodol in the diagnosis of spinal lesions, particularly spinal tumours. Its uses in the localization of pulmonary cavities, in genito-urinary work, in cases of fistula, and other conditions are discussed, and the last chapter is devoted to its therapeutic employment in a large variety of conditions, such as neuralgia of different kinds, lumbago, sciatica, arthritis, tenosynovitis, incontinence of urine, bronchiectasis, and abscesses.

There are many excellent radiograms, and the book is printed on better paper and produced in better style than are many French medical works. The lack of an index, however, is to be regretted.

The Sack-'em-up Men: An Account of the Rise and Fall of the Modern Resurrectionist. By JAMES MOORES BALL, M.D., LL.D. Medium 8vo. Pp. 216 + xxxi, with 81 illustrations. 1928. Edinburgh and London: Oliver & Boyd. 16s. net.

UNDER the bizarre title, *Sack-'em-up Men*, Dr. Ball gives an interesting, if somewhat discursive, account of the progress of practical anatomy throughout the ages, and dedicates it to the Council and Fellows of the Royal College of Surgeons of Edinburgh. Beginning with classical times, he traces the art of dissection century by century until he reaches the time when the supply of bodies in the United Kingdom was insufficient to teach the number of students who were obliged to learn. Then came the resurrectionists—mere grave-robbers at first, who became murderers in the end. Dr. Ball gives a full account of the Burke and Hare murders in Edinburgh, and of the Bishop and Williams murders which produced nearly as great a sensation in London. He mentions incidentally that similar practices occurred in the United States. It would serve a useful purpose if, at some future time, Dr. Ball would deal with the early teaching of anatomy in the United States, of the private schools in America, and of the work of such men as Abraham Chovet. Dr. Ball does not appear to have

a very deep knowledge of the surgical politics in London during the first quarter of the last century, with the result that he relies too much on the ex-parte statements which Thomas Wakley allowed to be published in the *Lancet*. The history of that stormy period still remains to be written in a judicial spirit. There is an error to be corrected on page 150, where it is clear that 'mail-coach' should be read for 'train'. Sir Astley Cooper sent a subject to Joseph Swan at Lincoln annually as a Christmas present, but there is no evidence that his hamper ever went by train. The illustrations are excellently reproduced and are well selected.

Annals of Roentgenology. Edited by JAMES T. CASE, M.D. Vol. VII, Urological Roentgenology. By HUGH H. YOUNG, M.D., Clinical Professor of Urology, Johns Hopkins University; and CHARLES A. WATERS, M.D., Instructor in Clinical Roentgenology, Johns Hopkins University, and Assistant Visiting Roentgenologist, Johns Hopkins Hospital. Imperial 8vo. Pp. 545, with 494 illustrations. 1928. New York: Paul B. Hoeber, Inc. $20.

THIS book is a most admirable compilation of radiographs, illustrating the advantages of the conjunction of the urologist with the radiologist in the diagnosis of pathological lesions in the genito-urinary tract. It is in reality an amplification of Young's *Practice of Surgery* so far as diagnosis is concerned. As the title indicates, it is chiefly composed of a collection of admirably selected and beautifully reproduced radiograms, which are so numerous that it is exceedingly difficult to think of a lesion of the tract which is not illustrated. If there is one criticism which might be made, it is that the illustrations appear as negatives rather than positives; however, they demonstrate quite clearly the lesions to which they refer.

There are two other factors which make the book exceedingly valuable: first, under each picture is given in a graphic manner a record of the case to which it refers; and, secondly, in a considerable number of cases there is a drawing of the pathological lesion placed side by side with the radiogram which led to its diagnosis, which shows how accurately this line of investigation can lead to an exact picture of the conditions present.

In the text a short résumé is given of the symptoms, signs, prognosis, and treatment of genito-urinary diseases, and thus, in addition to being an atlas of urological roentgenology, the volume serves as a text-book of genito-urinary diseases given in a sufficiently condensed form to make it useful as a book of diagnosis apart from the value of radiology.

The book is divided into ten sections, the first of which contains an excellent description of the gradual development of radiological methods as applied to the urinary tract, including a detailed account of those which are in use at the present time. This is followed by another chapter which deals with the anatomy and physiology of the urinary tract, special emphasis being laid on those portions of the anatomy which can be illustrated by radiological methods. The third chapter, as a natural sequence, deals with the various anomalies of the urinary tract demonstrable by similar methods of investigation. Subsequent chapters comprise a description of the appearances seen in connection with obstructions, infections, tubercle, calculus formation, tumours, and neurological lesions.

This is undoubtedly a valuable addition to the library of a surgeon interested in genito-urinary diseases, and to that of a practitioner who desires to have near him a book of reference with which he can compare an X-ray picture which he himself would otherwise have difficulty in interpreting. Moreover, it must also be of value to the radiologist who is not constantly performing this type of investigation.

The Normal and Pathological Physiology of Bone: its Problems. By Professor RENÉ LERICHE, Strasbourg, and Professor A. POLICARD, Lyon. Translated by Dr. SHERWOOD MOORE and Dr. ALBERT KEY, Washington. Medium 8vo. Pp. 236, with 33 illustrations. 1928. London: Henry Kimpton. 21s. net.

THERE can be no doubt of the originality and of the very great interest of this book. We are accustomed to expect original thinking from Professor Leriche, and we are seldom disappointed. The book is dedicated to Professor Ollier, of Lyon, and we

naturally expected to find it an elaboration of the theories laid down by this great pioneer. We have therefore been more intrigued to find that although the authors began with a full conviction of the truth of Ollier's teaching, yet after ten years' work they are firmly convinced that in some respects Ollier was wrong and MacEwen right, especially in regard to the functions of the periosteum.

We frankly admit that in some respects we do not understand the authors' meaning, and particularly in regard to the rôle of the osteoblasts. But they make it clear that they do not believe in the dominance of these cells in regard to the modelling of the architecture of the bone. We are left to wonder whether there is a specific virtue in the intercellular material, which dominates these cells and imprisons them in the adult structure of the bone. We find the whole book most interesting, from the first page to the last, and we very much hope that if a further edition is published the authors will be much more lavish with their illustrations of the actual facts in bone growth and repair.

We congratulate the translators on the very clear English version of the book, and they add to its interest by putting in various footnotes of protest whenever the original text appears to them too heterodox for acceptance.

A Handbook of Clinical Chemical Pathology. By FRANK SCOTT FOWWEATHER, M.D., M.Sc., D.P.H., F.I.C., Lecturer in Chemical Pathology, University of Leeds; Chemical Pathologist, Leeds General Infirmary. With a Foreword by Sir BERKELEY MOYNIHAN, Bart., K.C.M.G., C.B. Crown 8vo. Pp. 216 + xii, with 18 illustrations. 1928. London: J. & A. Churchill. 8s. 6d. net.

THIS small book has been written in order that those engaged in clinical work shall be able to realize the scope and limitations of various laboratory tests as an aid to diagnosis. On the one hand it is neither possible nor desirable that the clinician should carry out his own tests; on the other hand it is equally undesirable that the pathologist should be responsible for making a diagnosis. Methods of biochemical investigation have in recent years become so varied and complex that the average clinician knows very little of them. In the present work the physiological basis of various chemical tests is explained, with a short critical summary of the scope and value of each. No attempt is made to describe laboratory methods, the book being intended for the clinician and not for the laboratory worker. From the point of view of the surgeon the chapters on glycosuria, renal function, liver function, and the investigation of disordered conditions of the stomach, intestines, and pancreas are of the greatest value. We heartily congratulate the author on the brevity and clearness with which he has described the scope and indication for the various chemical tests.

Radium Treatment of Cancer. By STANFORD CADE, F.R.C.S., Assistant Surgeon, and Joint Lecturer on Surgery and Teacher of Practical Surgery, Westminster Hospital. Royal 8vo. Pp. 158 + viii, with 49 illustrations and 13 coloured plates. 1929. London: J. & A. Churchill. 15s. net.

THIS book has made a most timely appearance, because it gives exactly the information that is wanted about what is the most burning subject of modern surgery. One of the most pleasant and impressive points about the book is the short Preface, which unfortunately is called a Foreword. This Preface is written by nine men, who are the surgical colleagues of the author on the staff of the Westminster Hospital. It shows that the work represented by the book is the outcome of the activities of the entire staff of one hospital, but at the same time it affords a generous tribute to the enthusiasm and the initiative of Mr. Cade, who, it is stated, has been the inspiration of the movement.

The methods described are founded upon the work of two Continental clinics, namely, the Fondation Curie of Paris and the Radium Institute of Brussels. The first cases treated by radium, which form the basis of the present work, were undertaken five years ago. During this period certain types of cancer, notably those of the tongue and mouth, have less and less been treated by excision, so that now

radium has been established as the routine method for the primary operation. After three short chapters on radio-activity, methods of irradiation, and the general principles of radium therapy, a systematic account is given of the methods used in the various parts of the body. The general principle of treatment recommended is that of burying small doses of radium in and around the tumour for seven or eight days, and following this up by surface radiation for another prolonged period. It is held that the use of large doses for a short period does not kill all the cancer cells, but on the other hand endangers the vitality of healthy tissues. In cancer of the oral cavity the tumour itself is first irradiated, and then a week or two later the cervical glands are dealt with. At the present stage of the research it is, however, considered necessary to make a block dissection of the neck, removing the sterno-mastoid, internal jugular vein, and deep fascia. We confidently look forward to the time when this severe and mutilating operation may be dispensed with, because we cannot understand why glandular excision should be necessary for the neck if it is unnecessary for the axilla in cancer of the breast.

Next to cancer of the tongue, malignant disease of the breast and the uterus are the most important fields in which radium has been used. The technique described for the breast consists in burying radium needles in and around the tumour, in the upper intercostal spaces, above and below the clavicle, and in the axilla. These are left in place for one week, and then a few weeks later the back and front of the chest are subjected to prolonged surface irradiation.

The coloured illustrations are very convincing, and the whole book is clear and concise. Illustrative cases are given in each section, but we greatly desire to see some kind of statistical list, so that we may judge of the number of cases that have been treated and those which have given good results. It is impossible to commend the book too highly.

Diagnosis and Treatment of Deformities in Infancy and Early Childhood. By M. F. FORRESTER-BROWN, M.S., M.D. (Lond.), Surgeon, Bath, Somerset, and Wilts Central Children's Orthopædic Hospital. With a Foreword by Sir ROBERT JONES, Bart., K.B.E., C.B., F.R.C.S. Demy 8vo. Pp. 199 + xii, with 79 illustrations. 1929. London: Humphrey Milford. 14s. net.

THIS little book is a most important contribution to orthopædic literature and is bound to be widely read. Every page bears witness to the infinite pains the author has taken to present the subject in a simple and attractive style. Throughout, the importance of the early recognition of deformity as a means of preventing crippling is stressed. The postural deformities of the spine are particularly well described, and the exposition of Goldthwait's work on body mechanics in relation to posture could not be better done. The illustrations have been carefully selected and are all informative, but some of the figures are separated by several pages from the corresponding letterpress. This is a minor blemish in the format of the book, but no doubt there are good economic reasons for it.

Poliomyelitis: with Especial Reference to Treatment. By W. RUSSELL MACAUSLAND, M.D., Surgeon-in-Chief, Orthopedic Department, Carney Hospital, Boston, Mass. Medium 8vo. Pp. 402 + xi, with 173 illustrations. 1927. Philadelphia and New York: Lea & Febiger. $5.50 net.

POLIOMYELITIS has attracted so much attention in the last few years that a comprehensive study of the disease such as this volume furnishes will be welcomed by the profession. Dr. MacAusland would be expected to deal more particularly with treatment, and especially orthopædic treatment, but actually more than one-third of the volume is devoted to the subjects of history, epidemiology, pathology, diagnosis, etc., so that the work cannot be considered in any way one-sided. Moreover, the author has dealt with these general questions from a very wide standpoint, and has included an extensive consideration of literature and research.

In this country the diagnosis of poliomyelitis remains difficult and uncertain, so that perhaps 30 per cent of cases still remain undiagnosed in their early stages.

This is chiefly because of the absence of considerable epidemics, and as the author says, " The possibility of making a correct diagnosis is more certain under epidemic conditions, or when the infection occurs during the late summer or early fall." The chapter on diagnosis is a very valuable one, dealing fully with all the laboratory methods, and mentioning the more important conditions which may be confused with poliomyelitis. Under prognosis, again, there is much of value, culled from many records. An interesting observation of Draper's is quoted, showing that the cell-count of the spinal fluid gives an indication of prognosis. A low cell-count in the early stage indicates a transient paralysis, a higher cell-count a more severe paralysis, and a count of 700 to 1000 cells per c.mm. a fatal result. The experimental use of serum is recorded fully, although the conclusion has to be that " at the present time it is impossible to judge the efficacy of any kind of serum, whether normal or immune in form, or of animal or human source. The series of cases in which sera have been used have not been sufficiently large to permit us to draw any definite conclusions."

In the general symptomatic treatment of the paralytic stage Dr. MacAusland advises rest, but does not lay down at all clearly the length of time for which rest is required. The treatment at this stage is a point on which there is a good deal of divergence of opinion. Some would insist upon complete rest, involving immobilization, and even wrapping up the limbs in cotton-wool and avoiding so much as touching them at all over a period of four to six weeks; others go to an opposite extreme and use electrical treatment soon after the paralysis is established. It would seem to be important that a more definite decision should be made upon this point. The author's general account of the use of splinting or of plaster-of-Paris seems to aim rather at the prevention of deformity than at the maintenance of the position in order to secure muscular rest.

The latter part of the book is devoted to the orthopædic side of treatment. Here, naturally, the personal views and methods of the author come out more largely, but even the operative methods are made to include those of many surgeons, and are not in any way confined to Dr. MacAusland's own. There is a valuable chapter on muscle re-education, including definite instructions for systematic testing of the residual power in individual muscles and muscle groups, and also for the regulation of exercises given to them. With the operative methods recommended, orthopædic surgeons will agree or disagree according to their individual experience, but the author gives good general principles upon which these should be based. As an example may be cited the account of tendon transplantation, where the initial correction of deformity, careful selection of the muscle for transplantation, the importance of preserving the muscle unit and the gliding mechanism, and the secure insertion of the tendon to its new attachment, are all insisted upon.

The construction of the book is such as to render it easily readable, the illustrations are very good throughout, and there is an ample list of references.

Low Blood-pressure: its Causes and Significance. By J. F. HALLS DALLY, M.A., M.D., B.C. (Cantab.), M.R.C.P., Physician to Mount Vernon Hospital; Senior Physician to the St. Marylebone General Dispensary. Demy 8vo. Pp. 257 + xix, illustrated. 1928. London: Wm. Heinemann (Medical Books) Ltd. 15s. net.

THE author denies that low blood-pressure is compatible with perfect health, and considers that the condition is to be regarded as an expression of low vitality. There are many useful clinical observations in the book, and a good description of the method of measuring the arterial blood-pressure, but unfortunately it cannot be said that the subject is critically presented, especially in the chapters on etiology and on the endocrines, where there is much that is biochemically unsound. We note that the subcutaneous injection of oxygen is recommended in some cases of hypopiesis. It is easy to show by withdrawal and subsequent analysis that the injection of a quantity of oxygen equal to that used by the body in one minute is not entirely removed even at the end of twenty-four hours. Absorption by this route is too slow to be of any value. The book contains a few pages on surgical shock.

Handbook of Surgical Diagnosis. By CLEMENT E. SHATTOCK, M.D., M.S. (Lond.), F.R.C.S., Surgeon to the Royal Free Hospital, Paddington Green Children's Hospital, and to the Mount Vernon Hospital for Diseases of the Chest. Crown 8vo. Pp. 678 + viii, illustrated. 1929. Edinburgh: E. & S. Livingstone. 15s. net.

THE subject matter of this book is arranged like that of an ordinary text-book of surgery, from which it would be very difficult to distinguish were it not for the omission of the pathology, etiology, and treatment of the different diseases. The facts given are reliable, but the author has only been partly successful in his aim "to present in a practical manner the differential diagnosis of the commoner surgical affections", because he has not approached the problem from the point of view of the diagnosing practitioner who has to work backward from the prominent symptom which drives the patient to him. It is true that there are notable examples where this has been attempted—for instance, in the chapter on acute abdominal conditions—but they do not occur in sufficient numbers to invalidate this main criticism. In Chapter 27, headed 'Affections of the Neck', the author begins with great promise to consider solitary median fluctuating swellings of the neck, then solitary lateral fluctuating swellings, but spoils the very excellent plan of this chapter by making a large subdivision for the rest of it (save for mention of cervical fistulæ and pneumatocele) headed 'Thyroid Gland'.

The only illustrations are skiagrams. The author evidently considers X-ray appearances more important than the naked-eye external aspect of the patient. It is a peculiar decision to come to, for it is easier to give a word-picture of the appearance of an X-ray shadow which is monochromatic and lies in only one plane than of the three-dimensional, varying-coloured, diseased parts of the body. The book will be useful as a student's work of reference.

The Technic of Local Anesthesia. By A. E. HERTZLER, A.M., M.D., Ph.D., LL.D., F.A.C.S., Professor of Surgery in the University of Kansas. Fourth edition. Royal 8vo. Pp. 284, with 146 illustrations. 1928. London: Henry Kimpton. 25s. net.

THE fourth edition of this work has just been put on the market, and having reached this stage it may be said to have justified its existence. In form and composition it differs little from the previous editions. If any criticism is to be made, it is that the author occasionally leaves his subject for the domain of general surgery, and although he says in his preface that "the planning of the operation is more difficult than the technic of anesthesia", that is hardly an excuse for the setting forth of his views on the best methods of surgical intervention.

We also have the feeling that although the more difficult procedures are described in order to make the book complete, they are discarded after a merely cursory description in favour of a more detailed explanation of the method of doing the same operation under local infiltration. Splanchnic blocking, for example, is described as 'laborious and uncertain'. In spite of this, there is much commonsense in the book, and an attempt is made to distinguish between what should and what should not be done under local anæsthesia.

The volume is well illustrated and clearly printed, and if it is regarded as a general survey of the whole subject, rather than a work of reference for difficult points, it fulfils its purpose admirably.

Die Chirurgie der Brustorgane. By Professor Dr. FERDINAND SAUERBRUCH, Berlin. Vol. I, Part I, Diseases of the Lung. Imperial 8vo. Third edition. Pp. 916 + xxxvi, with 916 illustrations, many in colour. 1928. Berlin: Julius Springer. Bound, M.188.

WHEN completed, the present work will probably constitute the largest monograph on any medical subject extant. One's admiration for the immense labour involved in writing such a work is only equalled by the wonder that so many readers have time to peruse it. It first appeared in 1911 when Professor Sauerbruch was in Zurich; the second edition was published in 1920, the author then being at Munich; and the present edition—which will be in three parts, two devoted to the lungs and one to the heart—is edited from Berlin.

Of this first part of the first volume, 718 pages are devoted to general problems of anatomy, physiology, X-ray examination, operation principles, and narcosis. The remainder of the book is concerned with abnormalities of the chest wall and inflammatory affections of the lungs and pleura, ending with bronchial fistula and the treatment of pulmonary embolism.

The section on the anatomy of the chest wall and the lungs is by Walther Felix, of Zürich. It is not only very full and exact in its description, but it gives many mathematical statistics relating to the angle assumed by the ribs in different stages of respiration, and the elasticity of the ribs and their cartilages, which are of great scientific interest. The illustrations here and throughout the book are beyond all praise ; they are as perfect as illustrations can be. Some which call for special comment are those describing the course and relations of the phrenic nerves, and the figures of the upper opening of the thorax showing the relation of all the great blood-vessels to the trachea, lungs, and ribs. The detailed description and illustrations of the relations and branches of the vessels and air tubes, and also those of the lymph glands and vessels, are the best we have ever seen. The section on physiology is comparatively short, but this is accounted for by the fact that many physiological problems—e.g., the relative functions of the vagus and other nerves of the thorax, and the mechanism of respiration—are discussed under the headings of anatomy or pathology. General pathology deals with the questions of pneumothorax and its results upon all the intrathoracic organs. General principles of diagnosis include a description of the congestive phenomena associated with retrosternal goitres and mediastinal tumours, and also a rather short account of thoracoscopy.

Examination of the chest by the X rays is described by Chaoul, of Berlin. This section gives a very complete account of the normal and pathological appearance of the lungs, with typical pictures of the bronchial tubes filled with lipiodol, and also some most remarkable pictures showing the actual branches of the pulmonary vessels, infarcts, new growths, various inflammatory conditions, and the different varieties of tuberculous disease. Various diseases of the intrathoracic portion of the œsophagus and of the heart in relation to X-ray examination are very fully illustrated, so that this part of the work affords a veritable atlas of thoracic X-ray pictures which is invaluable for purposes of reference.

General principles of operative technique are introduced by a fairly complete set of figures of instruments, including a special operating table. The subject of anæsthesia is discussed at some length, with especial attention to local infiltration methods. A beautiful coloured illustration of fatal air embolus in the cerebral vessels is given.

Sauerbruch and his co-workers have spent much time and labour in working at the problem of the avoidance of lung collapse and pneumothorax when the chest is opened. We have here the whole case stated, and all the many complicated appliances, both of positive and negative pressure chambers and of special anæsthetic apparatus, are described and figured. But we venture to think that this is now chiefly of historical interest, and that progress in this as in other branches of surgery will be in the direction of simplification rather than elaboration.

The remainder of the book, 223 pages, deals with the actual surgical technique of operations upon the chest wall, lungs, and pulmonary arteries. It is difficult to single out any special part of this for comment or criticism, because it is so full and complete and so beautifully illustrated. The article on bronchiectasis is perhaps the most notable in this respect. It is probable that the more ambitious procedures—e.g., excision of a whole pulmonary lobe or ligature of one of the branches of the pulmonary artery—will make little appeal to the surgeon whose first consideration is the recovery of his patient. The simpler operations of artificial pneumothorax or phrenicotomy would appear to be those of choice ; for, though not producing a radical cure, they afford amelioration without undue risk to life.

The whole book is a wonderful monument of patient investigation, laborious work, and perfect publishing and printing.

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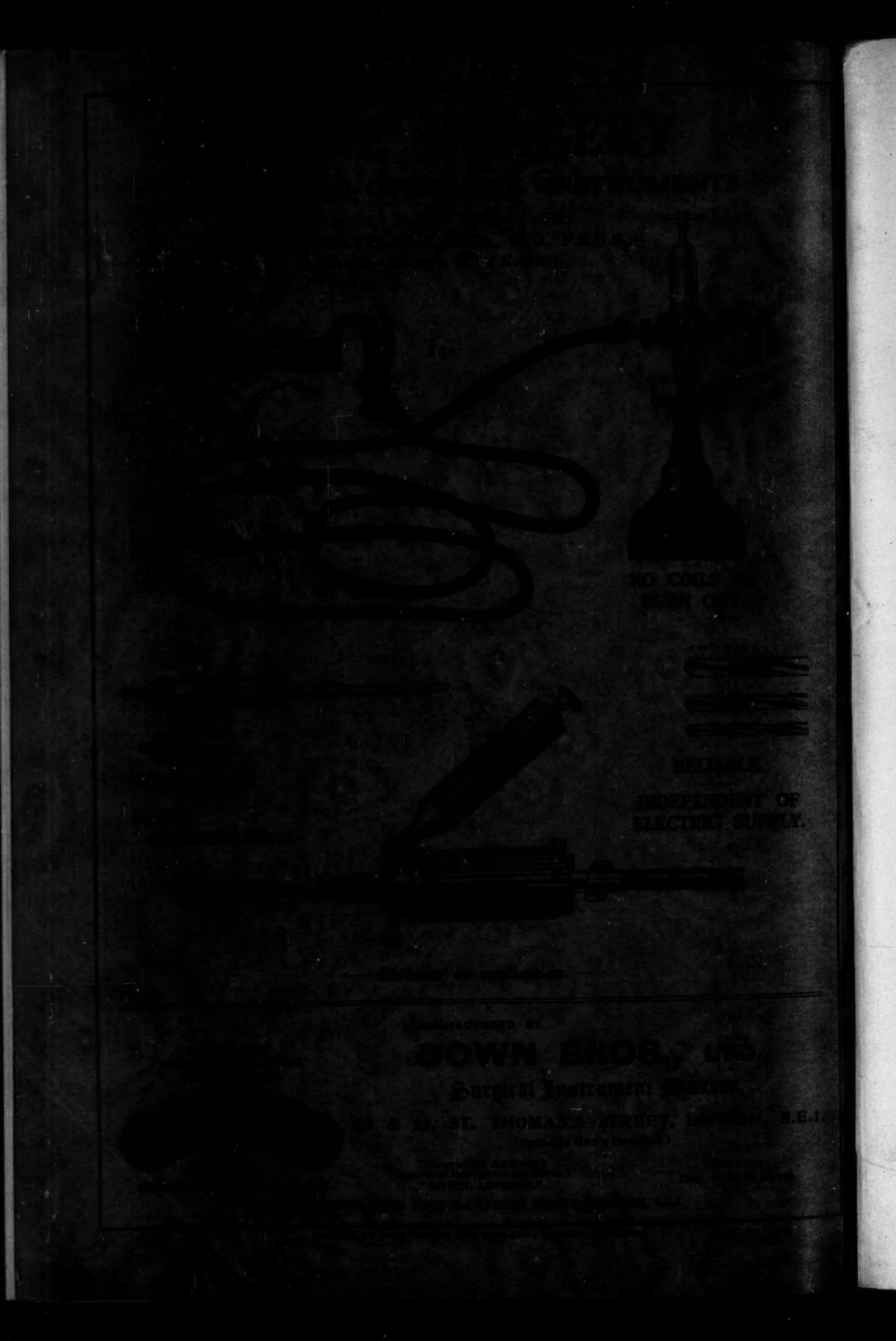
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